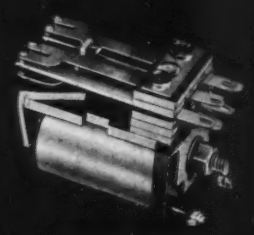
ngineering Materials and Design

Designing with Extrusions

page 143



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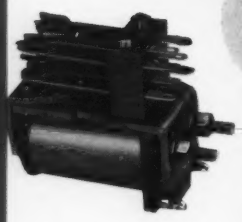
complies with RCS 166



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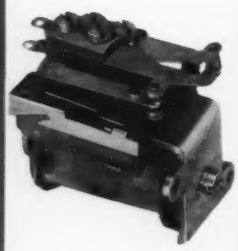
Miniature Relay



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★ *The Magazine for Engineering Designers*

A HEYWOOD PUBLICATION

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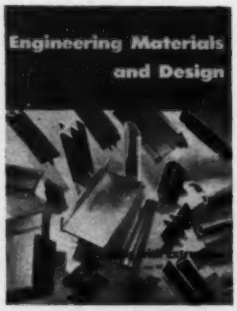

COVER—From a range of extrusions of this kind, the designer can make a selection for many structural and decorative uses. (Courtesy Southern Forge Ltd.)

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By **C. Z. Carroll-Porczynski.**

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Résumés

LES EXTRUSIONS A L'AIDE DES DESSINATEURS

T. E. G. Munro page 143

L'auteur présente une brève revue des possibilités des extrusions d'aluminium dans la construction et la décoration. Il examine plusieurs genres d'extrusions disponibles soit en unités standard soit fabriquées sur commande.

DESSIN DES PIÈCES FORGÉES

R. C. Jones page 134

L'article étudie les principes fondamentaux du forgeage et les caractéristiques que le dessinateur doit considérer ou éliminer selon les circonstances. Il offre des exemples détaillés précis de pièces forgées, en matrices ou par refoulement, et examine leur utilité pour ce genre de production.

FIBRES RÉFRACTAIRES DANS L'INDUSTRIE MODERNE

C. Z. Carroll-Porczynski page 159

Il est possible maintenant de fabriquer commercialement des fibres de silice fondue et cet article décrit les derniers progrès réalisés en Amérique. Ces matériaux ont une importance croissante pour les dessinateurs qui ont besoin d'un isolement capable de résister à des températures extrêmement élevées.

SOURCES DE RENSEIGNEMENTS TECHNIQUES

page 154

Une liste classifiée de près de 100 organismes dans le Royaume-Uni, prêts à fournir des renseignements techniques ou à aider les ingénieurs.

ALLIAGES DE MOLYBDÈNE ET DE TUNGSTÈNE

E. J. Sandford page 148

L'auteur passe en revue les progrès réalisés avec ces matériaux, métaux et carbures, et donne une idée de leurs possibilités en tant que métaux durs. Il mentionne également leur emploi dans la fabrication des outils et des lames tranchantes.

LES SILICONES DANS L'INDUSTRIE

B. F. Hayward page 163

Ces matériaux ont des propriétés uniques qui ouvrent des horizons nouveaux aux ingénieurs. L'article étudie leur emploi dans les produits diélectriques, le caoutchouc, les liquides et les lubréfiants, ainsi que dans les peintures et les produits relâchants.

Kurzreferate

STRANGPRESSPROFILE HELFEN DEM KONSTRUKTEUR

T. E. G. Munro seite 143

Eine kurze Übersicht der Möglichkeiten von Aluminium-Strangpressprofilen für Bau- und Dekorationszwecke ; die verschiedenen als Standardeinheiten oder auf Bestellung verfügbaren Typen sind ebenfalls besprochen.

SCHMIEDEKONSTRUKTION

R. C. Jones seite 134

Der Artikel bespricht die Grundzüge des Schmiedens und schlägt vor, was der Konstrukteur unter gewissen Umständen zu berücksichtigen hat. Er beschreibt besondere Beispiele von im Gesenkschmiedeverfahren und Stauchen erzeugten Teilen und untersucht deren Eignung für diese Produktionsform.

FEUERFESTE FIBERN IN DER MODERNEN INDUSTRIE

C. Z. Carroll-Porczynski seite 159

Es ist jetzt möglich, Silikafibern im Schmelzflussverfahren in kommerziellen Mengen herzustellen und neue amerikanische Erfahrungen werden in diesem Artikel beschrieben. Diese Baustoffe sind von besonderer Wichtigkeit für den Konstrukteur, der Isolierstoffe benötigt, welche auch sehr hohen Temperaturen widerstehen können.

TECHNISCHE INFORMATIONSQUELLEN

seite 154

Eine klassifizierte Liste von fast 100 britischen Organisationen, die bereit sind dem Ingenieur mit technischen Informationen zu helfen.

MOLYBDÄN- UND WOLFRAMLEGIERUNGEN

E. J. Sandford seite 148

Eine Übersicht über die Fortschritte in der Herstellung dieser Stoffe in Metall- und Karbidform, sowie über ihre Einsatzmöglichkeiten, wo harte Metalle benötigt werden. Der Artikel bespricht auch ihren Einsatz für Werkzeuge und Schneiden.

SILIKONE IM MASCHINENBAU

B. F. Hayward seite 163

Diese Stoffe zeichnen sich durch besondere, einzigartige, Eigenschaften aus, welche sie besonders im Maschinenbau wertvoll machen. Der Artikel bespricht ihren Einsatz als Dielektrika, Gummistoffe, Flüssigkeiten und Schmiermittel, sowie in Lacken und Auslösestoffen.

Резюме

ПРОДУКТЫ ЭКСТРУЗИИ В КОНСТРУКТОРСКОЙ РАБОТЕ

Т. Е. Г. Манро стр. 143

Статья дает краткий обзор возможностей применения алюминьевой экструзии в стройке или для украшения. Обсуждаются также различные продукты экструзии, как стандартные так и сделанные по заказу.

КОВОЧНАЯ КОНСТРУКЦИЯ

Р. С. Джонс стр. 134

Статья рассматривает основные принципы ковки а также факторы которые конструктору следует включать или исключать в определенных условиях. Описываются образцы деталей, обработанных либо ковкой в закрытых штампах, либо ковкой между открытыми бойками и обсуждается вопрос о том, насколько они подходят к такому виду производства.

ОГНЕУПОРНЫЕ ВОЛОКНА В СОВРЕМЕННОЙ ПРОМЫШЛЕННОСТИ

С. Ц. Карролл-Порчинский стр. 159

Теперь стало возможным изготовлять в промышленности сваренные, дивасовые, огнеупорные волокна и данная статья описывает прогресс, достигнутый в этой области в Америке. Этот матерьял приобретает все больше значения для конструкторов, нуждающихся в изоляции, способной вынести очень высокую температуру.

ИСТОЧНИКИ ТЕХНИЧЕСКОЙ ИНФОРМАЦИИ стр. 154

Классифицированный список около ета организаций в Соединенном Королевстве, готовых предоставлять инженерам техническую информацию и помощь.

СПЛАВЫ МОЛИБДЕНА И ВОЛЬФРАМА

Е. Ж. Сэндфорд стр. 148

Обзор успехов достигнутых с этими матерьялами в качестве металла и карбида а также потенциальных возможностей в тех случаях где требуется твердый металл. Обсуждается также применение этих матерьялов для инструментов и резцов.

СИЛИЦИЙ В МАШИНОСТРОЕНИИ

Б. Ф. Хэйуорд стр. 163

Этот матерьял обладает некоторыми уникальными свойствами открывающими новые возможности в конструкции машин. В статье обсуждается применение силиция в качестве диалектрика, в сочетании с резиной, в жидкостях, и в смазочных матерьялах а также в производстве красок и расцепляющих средств.

MATERIALS IN THE NEWS

Monthly Digest of Materials and Design News from Home and Abroad

Aluminium Laminate

THE TECHNIQUE of laminating wood, paper, asbestos and many other non-metallic materials to improve or modify their natural properties is well-established, but some interesting work at the Wright Air Development Centre, in the U.S.A., suggests that there are worthwhile technical advantages in building up a laminated structure in metals such as aluminium. Experiments have been made with 3½ thou. foil built up to thicknesses of the order of 0.05 in. with an adhesive which was cured under high temperature and pressure. These laminated structures have shown some interesting and potentially valuable properties. It is said that they can be made to have the same or possibly better strength properties than an equivalent solid sheet, that they are 7-10 per cent less dense than the parent metal foils and that their fatigue behaviour indicates that they retard crack propagation and possibly also crack initiation. This fatigue behaviour is possibly the most interesting aspect of the research. It has been observed that the sheet specimens of solid aluminium generally fail by the sudden propagation of a crack, whereas the laminates begin to tear and fail slowly in tension at the conclusion of the fatigue test. Furthermore the laminates appear to tolerate a somewhat longer crack than the solid sheets. This work is still in its early stages but the possibility of being able to manufacture a material which exhibits fail-safe properties makes it a development to be watched.

High Temperature Wire Coatings

FOR THE LAST FIFTEEN YEARS or more the manufacturers of enamelled wires have been striving to produce coatings that will withstand higher temperatures, so that they can satisfy the demand from designers of electrical equipment who find it either necessary or desirable to increase their ratings. This work has resulted in many new enamels appearing, but at best these latest materials are only suitable for use at temperature a few tens of degrees above the older oleoresinous enamels. Progress in aviation, missile technology and nuclear physics has, however, been so rapid that it has outstripped the research in the more normal organic coatings and attention it now being paid to inorganic materials for operation up to 600 and even 800 deg. C.

Attempts are being made in this country to use coatings of phosphate on silver plated copper wire. This method has been used successfully in the past for insulating transformer laminations but the problems in applying it to winding wires are largely associated with producing a flexible covering which will withstand a reasonable breakdown voltage. More promising perhaps is the discovery at Bell Telephone Laboratories which indicates that fluoride coatings having excellent flexibility, breakdown strength and high temperature resistance can be formed on copper and aluminium. This process opens up the possibility of a practical insulation for wires which can be operated at temperatures almost as high as the melting point of the metal.

An ingenious method of producing glass coated metal wires is reported from Russia. In this process small lumps of the metal, such as copper, are melted by induction heating inside a glass tube. From this molten mass a filament is drawn out at high speed. The metal core of the filament is surrounded by a glass film said to be of remarkable uniformity, concentricity and flexibility. Cores of 5μ diameter coated with glass 1μ thick are claimed to have been produced in this way and as the temperature resistance is virtually determined by the melting point of the glass it is believed that it is suitable for use up to 700-800 deg. C.

Another promising line of development is the use of ceramic coatings which are said to have been successfully employed on copper wire for the manufacture of transformers and f.h.p. motors by the General Electric Co. in the U.S.

In the medium (200-300 deg. C.) range silicone and fluorocarbon coatings appear to predominate and for the latter a recent announcement claims a new treatment to improve the bonding qualities. The process, called Raibond and developed by Radiation Applications Inc., uses radiation-graft copolymerisation and is said to produce a durable bonded coating which will not rub or wear off, without adversely affecting the electrical properties. This is believed to be an important advance in fluorocarbon coatings.

Prestressed Concrete on Show

IT IS USUAL to associate prestressed concrete with Freyssinet's original system and, although it is still essentially unchanged, many new methods and other improvements have been introduced in recent years. Not a few of these developments have been due to British engineers, and the recent exhibition organised by the Prestressed Concrete Development Group at the Institution of Civil Engineers has shown that the design of concrete structures, whether precast or not, is now on a strictly scientific basis. Bridge engineers have been considered ultra-conservative by many modern standards, but the fact that they now appear to accept prestressed concrete with enthusiasm for some of the largest bridges should encourage others in finding structural applications outside the civil engineering field. Already some success has been achieved in the construction of pressure vessels by Simon-Carves Ltd. and for these as well as pre-load tanks there are economic advantages, compared with metal, above a certain size.

Development in Leaf Springs

IT MIGHT NOT BE EXPECTED that leaf springs would make news but recently announcements have disclosed two developments which may be of interest to the designer. The first one concerns the results of research by Toledo Woodhead Springs Ltd. who have found by mathematical analysis that the multi-leaf spring as previously manufactured is unnecessarily heavy for its duty. They claim to have shown that a 20 per cent reduction in material can be made without in any way reducing the performance of the spring and furthermore springs to the new designs, by virtue of their uniform stress distribution, are not so prone to "Cupid's bow" distortion under load.

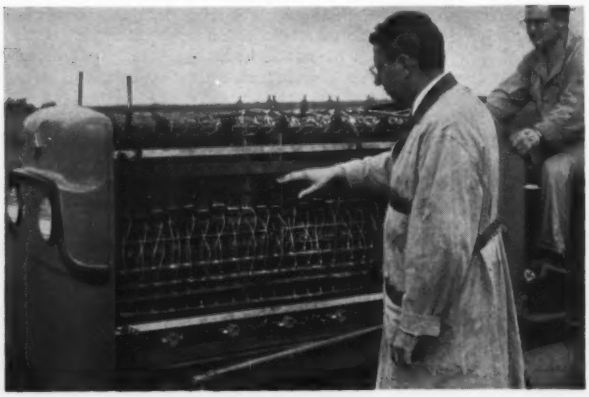
Certain applications of leaf springs, for instance on conveyors and shaker separating machines used in the chemical and mining industries, have to operate under severely corrosive conditions. For these the use of plastics has long appeared to have useful possibilities and it is now reported that by using glass reinforcement in a continuous non-woven pattern a very high flexural fatigue strength can be obtained. These plastics, known as Scotchply, are at present manufactured in the U.S.A. but are available in this country from the Minnesota Mining and Manufacturing Co. Ltd.

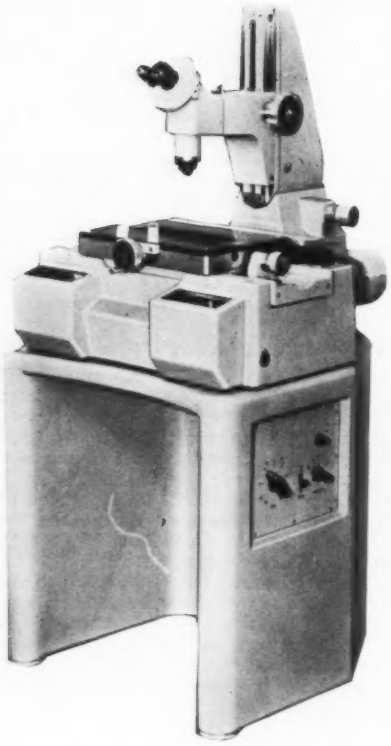
LONG-SUFFERING SILENCER

The silencer in the middle of these three was made of aluminium. All were subjected to equivalent road-testing periods under similar conditions, and the two conventional steel models are reported to have broken down. Reynolds Metals Co. say the new cast aluminium silencer will be on the U.S. market before the end of the year.

FUEL CELL TRACTOR

Electricity produced by 1,008 fuel cells powers this experimental Allis-Chalmers tractor. Chemical reactions between a mixture of fuel gases (largely propane) and oxygen in an electrolyte within the cells produce 15 kW of electricity. The direct current goes through the bus-bars shown above to a compact controller which regulates the speed and direction of the tractor by controlling the amount of current to the 20-h.p. motor.



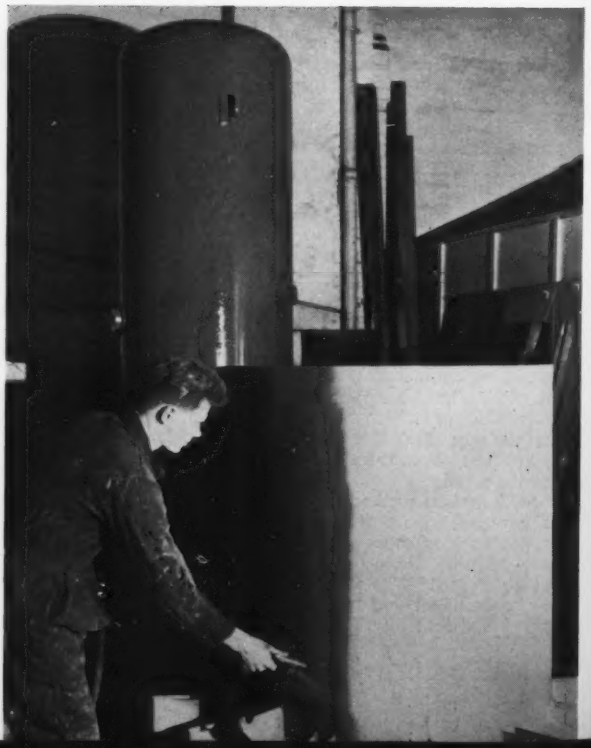


PICTURE NEWS

IN THE WORLD OF MATERIALS & DESIGN

JAPANESE ENGINEERING

A refreshingly modern appearance combined with high precision are the features of this Olympus-Kosaka optical toolmaker's microscope. Displacements as small as 5 microns are claimed to be possible by direct reading on a transparent glass scale. The table and base are of nodular cast iron, with wearing surfaces induction hardened.



AIRLESS SPRAY

The Bede airless spray process (used here to spray English Electric circuit breaker components) is based on achieving atomisation by a combination of straight hydraulic pressure, instead of compressed air, and vapour pressure, the latter being created in the material being sprayed by means of heat.

POLYESTER IN OXYGEN MASK ▶

Airmed Ltd. have recently developed a chain toggle for use with the latest pressure breathing mask for the R.A.F. The chain toggle device is mounted on an exo-skeleton fabricated from glass fibre-reinforced Bakelite polyester resin. The strength of the material prevents distortion of the mask at high pressures. Picture shows an exo-skeleton being assembled on to a mask.

ELECTRICALLY SUSPENDED GYROSCOPE

A scientist attaches a vacuum gauge to an electrically-suspended gyroscope made by Minneapolis-Honeywell. Gyros being developed by the company contain a beryllium sphere rotor machined to tolerances more accurate than 15 millionth of an inch. The sphere is electrically suspended in a vacuum and rotates at high speeds unassisted for long periods. This form of gyroscope is expected to provide greater accuracy.

SHAPELY COMPRESSOR

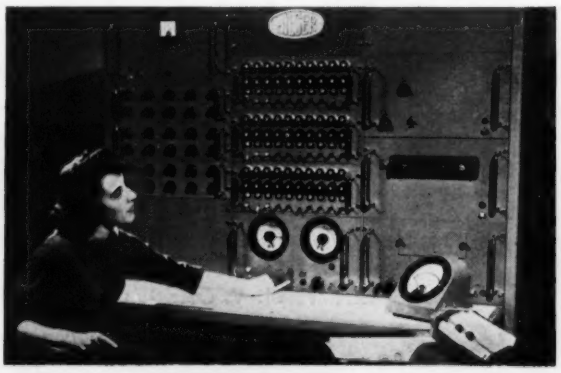
This Holman Rotair is the first British portable screw-type rotary compressor; it provides 600 c.f.m. of compressed air at 100 p.s.i. for rock drills and other pneumatic mining equipment at a U.K. A.E.A. site in Cornwall, where underground tests with conventional explosives are being made. It is also notable for the styling of the compressor canopy; the upper half can be removed for easy maintenance.

HIGH-PURITY CHROMIUM ▼

This is a crystal bar of the purest chromium (99.99 per cent.) now available. This bar was prepared at the Battelle Memorial Institute by a process utilising the thermal decomposition of chromium iodide. The metal will enhance the fabricability and ingot yield of present wrought commercial chromium-containing alloys. Its properties are expected to be useful also in obtaining the ductile chromium-based alloys sought for space travel work.

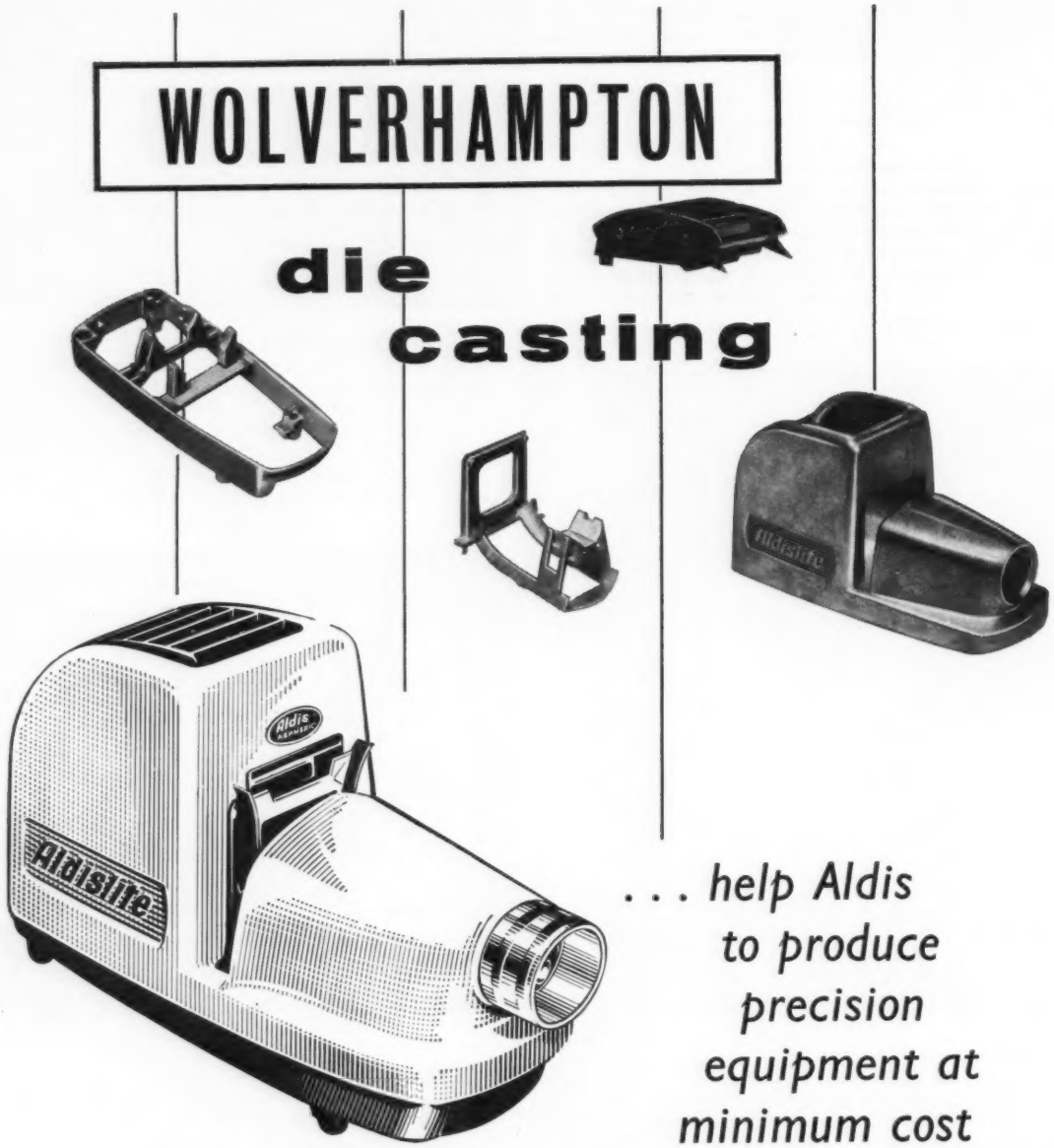
CHEMISTS AT WORK—1960 ▼

Not a telephone switchboard, but an electronic measuring console which is the heart of an electronic spectrometer installed by Jessop-Saville for analysis of special steels, titanium, zirconium and other alloys. Results are automatically typed on the electric typewriter.



WOLVERHAMPTON

die casting



. . . help Aldis to produce precision equipment at minimum cost

Precision, strength and high-quality finish—these are the prime requirements of Aldis Brothers Ltd. for their Aldislite Slide Projector.
WOLVERHAMPTON die castings meet these requirements, in the largest and most modern plant in the country, backed by nearly half a century's experience in the making of quality die castings.

THE WOLVERHAMPTON DIE CASTING CO. LTD.

GRAISELEY HILL WORKS, GRAISELEY HILL, WOLVERHAMPTON Telephone: 23831/6

Half a million square feet devoted to the production of better die castings

High Temperature Tubing

BERYLLIUM OXIDE CERAMIC TUBING in lengths to 24 in. highly resistant to elevated temperatures and to thermal shock, is now being produced by the National Beryllia Corp. The tubing is supplied with both ends open or with one end closed, for insulation and protection of thermocouples and other sensing and measuring elements for use at extremely high temperatures or where heavy radiation is encountered. The tubing is also used to introduce materials to, or draw samples from, areas where temperatures are very high or corrosive conditions are extreme.

Properties claimed for the tubing include melting point of 2580 deg. C., greater strength above 1100 deg. C. than any other known ceramic, high hardness and abrasion resistance, high electrical resistivity combined with high thermal conductivity, and immunity to heavy doses of radiation. The exclusive high-fired surface is permanently dust-free, thus eliminating toxicity problems. Because of high density, the tubing is essentially gas-tight.

Poppet Valve Outboard Motors

ONE OF THE MOST IMPORTANT FEATURES of the Perkins 35 h.p. outboard is the use of poppet inlet valves in the crankcase. Although these are similar to the poppet valves in car engines, they are not used in any other British outboard but they ensure a smooth flow of power at normal operating speeds and regardless of varying atmospheric pressures. In addition it is possible to dispense with the bulky silencer. This makes available a lighter, faster engine giving maximum load-carrying capacity and economy. The power generated at the head is delivered direct to the propeller through the special dura-drive lower unit.

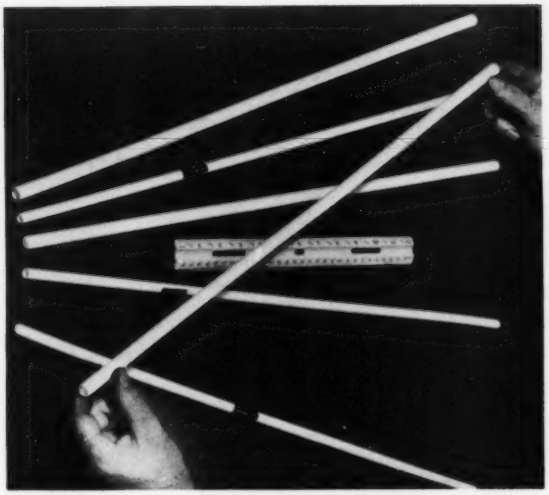
By using this simple and compact single-unit gear assembly, fuel is saved, initial drive is increased, and the boats may be planed faster and skiers brought up more easily. The unit is housed in a streamlined one-piece casing with minimum of parts and the smooth rounded leading edge is designed to slip over underwater objects. The dura-drive gear assembly allows closer tolerances, involves fewer parts and results in more efficient operation with less maintenance. The propellers are protected with a rubber cushioned hub to absorb the shock of striking underwater objects or the bottom.

News of Stainless Steel

NEWS THAT Firth-Vickers Stainless Steels Ltd. and Samuel Fox & Co. are expanding their production capacity of stainless steel is probably not likely to excite the average engineer or set him thinking about improved designs of his own products. But in fact this news is very significant as it is the result of steadily increasing demand from almost the whole of industry. It is particularly interesting to note that new developments in engineering equipment often incorporate some form of stainless steel, which is having large scale application in dairies, breweries and chemical plant generally. The increasing use of stainless steel for domestic and catering equipment is fairly obvious, but it is not generally appreciated that the motor industry is responsible for an unprecedented demand for decorative trim.

Stainless steel offers the designer wonderful opportunities to ease the burden of the maintenance engineer in oiling and painting parts which normally rust; by using a resistant material the designer can also protect himself from the all-too-common mechanism failure caused by poor maintenance, where equipment is used under corrosive conditions or where it is used only intermittently and stored under damp conditions. The increasing use of stainless steel has led to a demand for improved machining rates, and special free-cutting qualities are produced by Kayser, Ellison & Co. who claim that the surface finish produced by machining these materials is so good that final polishing operations can be omitted.

Fire-back boilers of stainless steel are beginning to challenge their traditional copper counterparts, particularly in their application to the closed type of solid fuel appliance, in which severe corrosion problems have been encountered. Stainless steel boilers are now being made by the Dartmouth Manufacturing Co. and although their initial cost is slightly more than the older copper boilers their life is said to be much longer.



Examples of beryllium oxide ceramic tubing (see "High Temperature Tubing").

The boilers are of welded construction using the Argonarc (British Oxygen Gases Ltd.) process.

In heavy industry some interesting applications of stainless steel are reported by Hadfields Ltd. who make the finshafts for Denny-Brown ship stabilisers from this material. They also point out that the trend in paper mills design is towards larger outputs, leading to the manufacture of rolls which are larger and more highly stressed. Non-ferrous materials are not strong enough in certain cases and stainless steel has been substituted. Hadfields also refer to recent developments in producing the so-called precipitation hardening alloys where a combination of corrosion resistance and high hardness can be obtained. One advantage claimed for this group of materials is that components can be finished machined and then finally hardened without significant distortion.

The term stainless steel covers a very large range of different steels and it is extremely important that the correct type of steel is chosen for a particular purpose. Firth-Vickers Stainless Steels Ltd., believed to be the only British company devoted exclusively to these special steels, provide a technical service to anyone interested in the use of these materials.

'Packaged' Substation Development.

A TREND said to show considerable savings in installation and running costs is the use of indoor "packaged" substations instead of conventional equipment installed outside a production area. A typical installation is at the Mersey Docks & Harbour Board, where an English Electric Superform switchboard controlling the outgoing circuits is coupled to a 250 kVA dry-type transformer in the same sheet steel enclosure.

A "packaged" unit of this type can be installed at a load centre to feed out radially to individual loads. The transformer and the medium voltage switchboard are coupled directly together, reducing the overall amount of space required and shorter cable runs save copper costs and voltage drop. No oil drainage pit is needed for the dry-type transformer which is air-cooled by air circulation through specially designed louvres on three sides of the transformer compartment. No fire protection services are necessary as there is no oil used in the installation and negligible fire risk reduces insurance premiums. The unit may be mounted within the roof girders of a factory and feed down to the individual loads, thus saving valuable production floor space. If the load increases, the transformer, which is mounted on wheels and runs on guide rails, can easily be withdrawn and a transformer of higher rating substituted.

A "packaged" unit incorporating a 500 kVA transformer is to be shown at the Electrical Engineers (A.S.E.E.) Exhibition at Earls Court from April 5-9.

E.M.D. 2327 for further information

NICKEL ALLOY STEELS

ensure reliability in fire fighting appliances

Long days of relative calm interspersed with short bursts of furious activity provide the continuing test of reliability for fire fighting appliances.

Into the design of the fire fighting vehicles of Dennis Bros. Ltd., Guildford, have gone decades of experience which have taught them the importance of specifying materials which will not fail. In the appliances are nine nickel alloy steels, notably the nickel-chromium case-hardening steel EN 36, which is used for the gear box gears and for engine components. By such thoughtful measures, equipment breakdowns and resultant disasters are alike avoided.

Typical core mechanical properties of 3 per cent nickel-chromium steel

EN 36

ARE GIVEN BELOW:

SIZE	HEAT TREATMENT	MAXIMUM STRESS t.s.i.	ELONGATION per cent	IZOD ft. lb.
1½" dia.	Oil quenched 780°C.	72·0	19	69
2½" dia.	Oil quenched 860°C. Oil quenched 780°C.	62·7	19	67
3" dia.	Oil quenched 860°C. Oil quenched 780°C.	59·7	22	72

The benefits to be gained from the more highly alloyed case-hardening nickel steels, such as EN 33; EN 34; EN 36 and EN 39 include ease of heat treatment, minimisation of processing distortion, higher load-carrying capacity, and general reliability.

Send for 'The Mechanical Properties of Nickel Alloy Steels' ▶

TGA 21/25

MOND NICKEL

THE MOND NICKEL COMPANY LIMITED, THAMES HOUSE, MILLBANK, LONDON, S.W.1

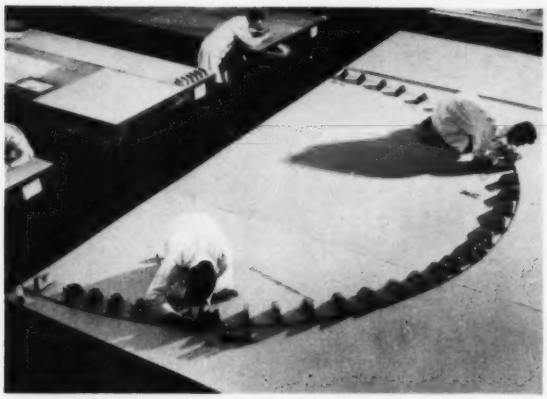
Lofting Aircraft

THE PROCESS of full-scale "lofting" was introduced in the aircraft industry during the war. The term, of course, derives from the early shipyard practice of preparing full-scale drawings in a loft, because it was the only place where there was enough room. One of the biggest drawing projects ever undertaken by the British aircraft industry is now being tackled by layout draftsmen at Short Brothers and Harland at Belfast.

The huge dimensions of the S.C.5. Britannic, which has a fuselage 136 ft. long and 17 ft. 7 in. diameter, mean that the men have to draw the full-scale plans of the giant freighter while kneeling on the huge table tops, the largest of which measures 120 ft. x 20 ft.

To accommodate this new arrangement the layout of the existing lofting department had to be altered and extra table space provided to accommodate the specially-treated metal sheets. From these master drawings, duplicates are produced lithographically on metal to make templates which will be used by machine tool operators to produce the Britannic components. For the sake of speed, other companies are collaborating: Bristol Aircraft Co. are designing and lofting the wings, and Saunders-Roe are handling the tailplane and rear fuselage.

The work of a lofting department serves a dual purpose. Not only does it provide master drawings from which duplicates are made for use in production, but it also verifies the shapes and contours of the different components of an aircraft after the initial design has been established.



Draftsmen working in the lofting department of Short Bros. & Harland, preparing the layout for the half section of a standard frame, 17 ft. 7 ins diameter, in the centre portion of the Britannic's fuselage.

Continuous-Cast Bronze

TO PROVIDE THE high strength and exacting precision and the ability to withstand many years of immersion in highly corrosive waters demanded by a Chicago drainage project for sluice gate operating stems, bronze alloys, precision cast by a continuous process developed by American Smelting and Refining Co., have been used. These nine 20 ft. Ni-Vee bronze stems, each 4½ in. in diameter and weighing 1,300 lb., now operate the sluice gates of the recently completed Lockport, Ill. flood control project.

It is claimed to be the first time that continuous casting of Ni-Vee bronze to such length and diameter has been attempted. The successful combination of metallurgical properties was achieved through the careful control of alloying elements, coupled with high density, uniform grain structure and freedom from porosity.

Unsupported along its entire length, each stem has to bear a combined torque and axial load of 2,500 ft. lb. and 56,000 lb. respectively. In addition, the stems have to withstand long periods of immersion in water of very high pH content, investigations having revealed corrosion to be a far more frequent cause of stem failure than lack of adequate physical strength. It was essential, therefore, that the material should be both strong and corrosion resistant.

Before the final choice was made various materials were considered. Manganese bronzes had the requisite strength characteristics but, because of their high zinc content, might be subject to dezincification in the highly alkaline waters. Stainless steels met the requirements for strength and corrosion resistance but were not chosen because costly machining operations would have been necessary.

Finally, John Mohr and Sons, of Chicago, the engineers responsible for the fabrication and installation of the nine sluice gates, turned their attention to one of the Ni-Vee bronzes developed by the International Nickel Co. The alloy selected contains only 2 per cent zinc and is consequently not subject to dezincification. With heat treatment, it could be brought up to the required strength.

By using the continuous casting process it was possible to guarantee such fine tolerances that the need to machine the stems before threading them was eliminated.

THE APRIL ISSUE

of Engineering Materials and Design will include the following main features:

A Survey of Permanent Magnet Materials
Selection guide to types of materials available.

Simplified Gear Calculations
Design data for spur gear measurement.

Friction Location on Shafts
Using taper bushes for shaft location.

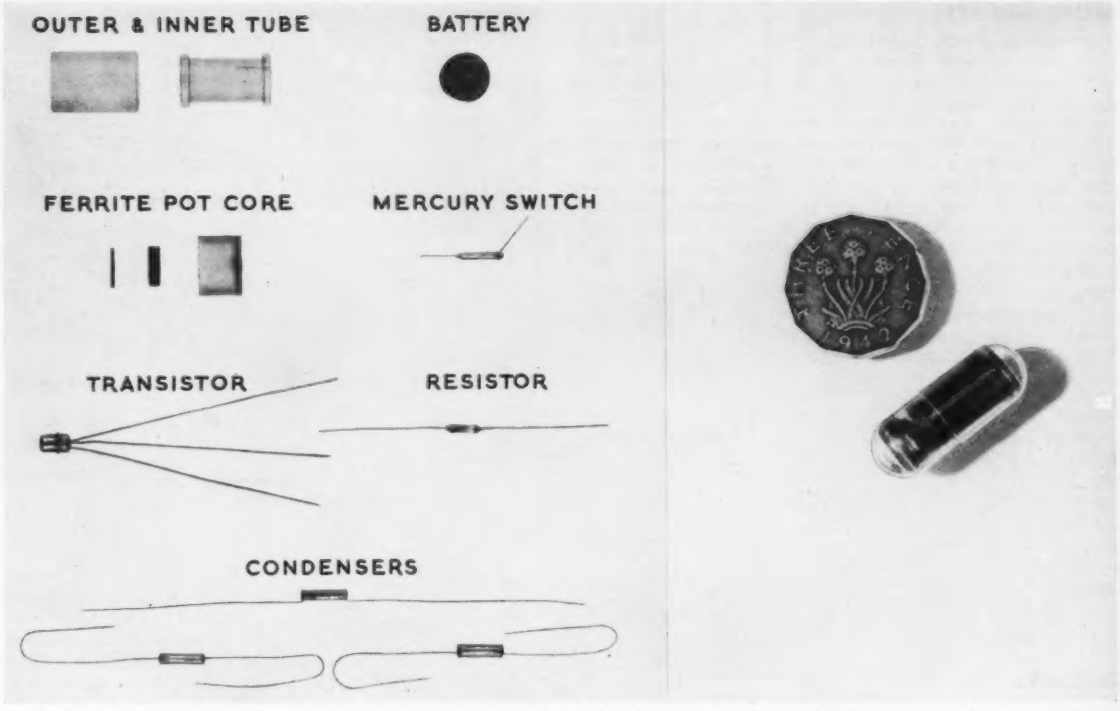
Trends in Conveyor Belting Materials
How modern materials have improved performance.

Atomic Hydrogen Welding Techniques
Advantages and practice of these methods.

Inorganic Plastics

TO TALK ABOUT PLASTICS being inorganic may sound to many engineers a confusion of terms because most of the present-day plastics are too obviously carbon-containing when subjected to excessively high temperatures. This very fact, however, has led to intensive activity in many countries for materials which combine the high temperature characteristics of inorganic materials such as ceramics with the impact resistance and easy formability of plastics. The reason for calling these new materials plastics is that they are built up with a polymeric structure of the same general character as the more familiar plastics and truly belong to the same group.

The first step towards producing an inorganic polymer was the production silicones which are believed to owe a high temperature resistance to the fact that their main backbone structure does not contain carbon although their side attachments do. Silicones as they exist today are not usually recommended for operation at temperatures above about 300 deg. C. However the Russians claim to have produced modified silicones for operation up to 600 deg. C. but it is understood that they do not exhibit elastomeric (rubber-like) properties. Some promising activity is going on in the U.S.A. on the synthesis of boron-containing polymers, associated with other non-metals such as nitrogen or phosphorus. Another distinct group are the materials based an aluminium-oxygen backbone being investigated by the University of Illinois and at W.A.D.C. All these materials are discussed by Dr. V. E. Yarsley at the Engineering Materials and Design Conference in a paper to be read on Feb. 23 at Earls Court.



This "pill" radio transmitter was shown at the Physical Society Exhibition by the Medical Research Council. It measures 1.8 cm. long and is 0.8 cm. diameter.

Physical Society Exhibition

NO BETTER illustration of the importance of research to engineering could be seen than at a visit to this exhibition. The barriers between different sciences and between science and engineering are fast disappearing so that an exhibition which, on the face of it, might appeal only to laboratory technicians and scientists, contains much advance information for the practical engineer.

Solid state physics, the term used to denote a vast subject covering semiconductors and similar devices, has made such rapid advances that engineers must watch its progress with detailed interest for it may ultimately mean the elimination of many time honoured engineering devices such as shafts, gear trains, motor and relays. In this field, the A.E.I. silicon controlled rectifier is a development of great promise, having many of the characteristics of the gas-filled thyratron for d.c. motor control but without some of its disadvantages. Apart from an inherent psychological repugnance to the use of valves, electrical engineers will find that the new rectifier has additional advantages in that no warm up time is required and a lower forward voltage drop is claimed, giving it a higher efficiency.

A glimpse into the future of electric power generation was shown on the A.E.R.E. Harwell stand where three methods of direct conversion of heat to electricity were shown. Great interest on an international scale is being shown in these methods particularly in conjunction with nuclear reactors. The use of diodes, semiconductor thermocouples and the magnetohydrodynamic method (M.H.D.)—the latter suggested independently by Prof. Thring of Sheffield University and Avco in the U.S.A.—may all find a place in the practical generation of electricity, and if efficiencies can be raised, as there is every indication they will, then the design of steam plant and rotating generators will be greatly affected.

In the field of instrumentation and automatic control the use of transistors and other semiconductors has already created a minor revolution. A host of new measuring elements such as the Plessey "Hall effect" detector for measuring magnetic fields in the microgauss region and transducers like the indium antimonide unit shown by the N.R.D.C., for remotely indicating minute displacements are likely to be valuable research tools for investigations leading to new designs or searching into causes of failure. Much has been written recently on the development of Peltier cooling and a neat application of this principle to instrumentation is the thermoelectric recording hygrometer shown by the A.E.I. Research Laboratory, Aldermaston.

Measurement of flow of a liquid often poses difficult problems when the conditions are highly corrosive or where it is undesirable to introduce a pressure drop in the pipe; therefore the ultrasonic flowmeter shown by the British Scientific Instrument Research Association was of unusual interest. The principle of this method is to measure the transit time of an ultrasonic beam upstream and downstream between crystal transducers. If there is no flow the time will be the same in both directions but when there is flow the time difference is proportional to flow velocity.

One of the most intriguing exhibits was the "pill" radio transmitter shown by the Medical Research Council. An excellent piece of micro-miniaturisation, this transmitter measures only 0.8 cm. diameter and 1.8 cm. long, so that it can be swallowed without difficutly. A temperature or pressure sensitive transducer is built in and frequency modulates a battery-operated transistor oscillator and so enables the gastro-intestinal canal of a patient to be examined without the use of tubes or wires. A minute mercury switch which is operated by giving the unit a "thermometer" flick enables the battery to be switched on and off as required.

FOR MORE INFORMATION:—

National Beryllia Corp., 4501 Dell Avenue, North Bergen, N.J.
Short Bros. & Harland Ltd., Seaplane Works, Queens Island, Belfast.
Hadfields Ltd., East Hecla Works, Sheffield 9.
Bristol Aircraft Ltd., Filton, Bristol.
Toledo Woodhead Springs Ltd., Coronation Works, Aycliffe, Nr. Darlington.
Wright Air Development Center, Wright-Patterson Air Force Base, Ohio.
Firth-Vickers Stainless Steels Ltd., Staybridge Works, Sheffield 9.
Samuel Fox & Co., Stocksbridge Works, Nr. Sheffield.
Kayser, Ellison & Co., Carlisle Steel Works, Sheffield 4.
Dartmouth Manufacturing Co., West Bromwich, Warwicks.
Bell Telephone Laboratories Ltd., 463 West Street, New York 14, N.Y.
General Electric Co., 1 River Road, Schenectady 5, N.Y., U.S.A.
Prestressed Concrete Development Group, Terminal House, Grosvenor Gardens, London, S.W.1.
Perkins Outboard Motors Ltd., Peterborough.
English Electric Co. Ltd., Marconi House, Strand, London, W.C.2.

AN EXHIBITION FOR THE DESIGNER

IN post-war years there has been a noticeable tendency for exhibitions to become more and more specialised. The trend has not been wholly bad, for specialised exhibitions are to be preferred to general trade exhibitions which are so wide in their scope that no section of the community is interested in more than a very small number of exhibits. It is, however, not without its disadvantages for the engineering designer who now has to visit a great many exhibitions in order to cover all his interests. In practice, he probably cannot find time to visit more than two or three in a year, and it is likely that at any one exhibition only a small number of stands will be of direct concern to him.

In sponsoring, jointly with *The Financial Times*, the first Engineering Materials and Design Exhibition and Conference at Earls Court (February 22-26), we have tried—as we do with this journal—to foster the interests of the engineering designer by planning an exhibition and conference specially for him. In this way we hope to serve the interests of the exhibitors as well as engineers, for the exhibitors will on the one hand be given an unparalleled opportunity to meet many designers who are seriously interested in their products and on the other a chance to talk to the man on the drawing board without having to go through the purchasing department.

The problems of organising a conference are considerable and some designers have expressed their disappointment that many subjects have been omitted from the programme, such as welding, bearings, aluminium, nickel alloys and couplings. It has also puzzled some people that we have mixed up in one conference some very specific subjects, such as beryllium and shaft seals, with much more general lectures covering appearance design. It must be appreciated that to cover engineering in one week would involve such a superficial treatment that it would consist of a stream of generalities which would not interest any engineer earning less than £10,000 per year! If the subjects are to be given adequate detailed treatment then it is inevitable that something must be omitted and whilst we are very sorry to disappoint those who have looked for their particular interest in vain, we can only express the hope that there will be further opportunities to fill in some of the gaps at future conferences.

We have mentioned that the intention is to provide an exhibition and conference for the engineering designer, but we place a large proportion of the responsibility for its success on his shoulders. Too often the engineer waits and expects supplier firms to contact him with their latest products and developments, but how can they possibly know the engineer's problems unless he makes them known? We suggest that readers should visit the exhibition with the firm intention of disclosing their problems and requesting help. And to exhibitors may we suggest that you have some large pads of paper handy. You know how engineers love to scribble!

After all we have said about aiming the exhibition and conference at the engineering designer, we hope that readers will let us know their views on what they liked and disliked. Whether it be a criticism or a helpful suggestion, we must know what you think. This will be of great help to the organisation of any future shows and will give you a chance to help in shaping its future.

See you on Stand 36.

The Editor

FUSED SILICA FIBRES FOR USE AT HIGH TEMPERATURES

The development of fused silica fibres is of increasing importance to the designer searching for materials able to withstand elevated temperatures. The latest developments of these are discussed here

by C. Z. CARROLL-PORCZYNSKI*

SILICA, the most abundant mineral in the earth's crust, occurs in nature in many forms and degrees of purity, such as nearly pure quartz in crystalline or massive form or quartz sand. Quartz is characterised by the following physical properties:

Hardness (Mohs):	7
Specific gravity:	2·6
Softening point:	1,500 deg. C.
Melting temperature:	1,710-1,756 deg. C.

In view of the fact that during the growing stage of fibre production, quartz structure changes from crystalline to amorphous, all fibres produced from this material will be described as fused silica fibres instead of quartz fibres, under which name they are usually marketed.

The use of fused silica fibres[1, 2, 3] in precision measuring instruments, particularly in microbalances where their high strength in tension and torsion, and almost perfect elasticity coupled with resistance to chemicals (insoluble in all acids except hydrofluoric), offer great advantage over other materials.[4] One of the simplest and most widely used fibre balances is the helical spring type. This is frequently employed for sorption measurements, density determinations, measurements of heat loss and evaporation.[5] The fused silica fibres are also used in such instruments as galvanometers, magnetometers, electroscopes and electrometers,[6] in low-pressure manometers,[7] in radiometers and in ionisation chambers.[8]

Early attempts to produce fused silica fibres on a commercial scale were hampered by the lack of availability of stocks of transparent quartz rods, free from impurities and from which fibres could be drawn. One of the successful methods of producing quartz rods was developed by H. C. Lacell and W. A. Shenton, and soon thin fused rods were used for the manufacture of quartz wool.[9] Machines were also developed for the continuous drawing of fused silica fibres.[10, 11, 12] The streamlined version of such a machine has been developed by W. C. Heraues Gesellschaft, the wool being finally collected on a rotating drum.[13, 14]

Wool Type of Fibres

The development in the U.S.A. of commercial processes by Glan Fibers Inc. for producing fine fused silica fibres has opened up entirely new fields to this material. These fibres, currently marketed by Johns-Manville as Micro-Quartz, average in diameter only 1·0 micron, and are available in the form of a flexible felt or in bulk form.

The felt made from these fibres possesses many outstanding properties, the most important being its resistance to temperatures as high as 1,370 deg. C. It may be used alone or in combination with other heat-resisting materials. The usual practice is to apply quartz felt to the hot side and a less expensive insulating material (such as glass wool or rock-wool felt, having lower working temperature limits) to the outer or cooler side of the composite insulations. The felts are particularly suited to applications where a maximum thermal insulation must be obtained with minimum thickness.[15] These fine fibres are also used in the electrical industry, in nuclear-power plants, jet aircraft, turbines and guided missiles.[16, 17] Fine fused silica fibres are also being employed as electric heating mantles.[18]

It is claimed that Micro-Quartz insulating materials combine excellent thermal conductivity with high-temperature resistance. Data shown in Fig. 1 were obtained from tests run at five mean temperatures from 38-760 deg. C. At a mean of 760 deg. C., the hot surface temperature was 1,250 deg. C. The flatness and straightness of the curve indicate unusual performance for material of 3-lb. density.

The following test was carried out in order to ascertain the resistance to vibration of the felt material: a 4-in.-diameter pipe, 3 ft. long, was insulated with a 1-in. thickness of Micro-Quartz felt. Thermal conductivity was measured at three mean temperatures. The insulated pipe

* *Manager, asbestos division, Metal Traders Ltd.*

was then placed in a high-frequency vibration apparatus, and the assembly was vibrated for 48 hr. at 100 c/s and an amplitude of 0·02 in. The assembly was returned to the high-temperature tester, where thermal conductivity was again measured at the same hot-side temperatures, and the two test results were compared.

The average increase in thermal conductivity (at three mean temperatures) was 1·5 per cent. This figure, within the limits of reasonable test error, indicates little or no change in efficiency as a result of the vibration exposure.

While reviewing recent developments in the wool type of fused silica fibres field, mention should be made of the production of platinised fibres for use as a catalyst.[19]

Continuous Filament

A method was recently described of producing continuous filament fused silica fibres of great uniformity and great fineness. In this process a quartz rod 2 to 0·2 mm. thick is pushed at a constant low velocity to a suitable hydrogen or illuminating-gas flame. From softened rod, a thread is drawn out at a very high speed and wound on a polished drum.[20]

It has been reported that the tensile strength of filaments thus formed increases with decreasing thickness. The highest strength recorded, approaching 650 kg./mm.^{2}, was that of fibres 0·8 μ thick. The torsion modulus proved to be independent of the fibre diameter up to 1·5 μ.[21]

An interesting apparatus for the production of fused silica continuous filament yarns has recently been patented.[22] This is also suitable for the manufacture of fused silica filaments from a powder mixture instead of a solid rod.

Fused Silica Yarns and Fabrics

The U.S. General Electric Co. has developed recently a method of production of silica continuous filament yarns (marketed as quartz yarn) which can be processed on conventional textile twisting, doubling and winding machinery. At present only 200-filament yarn is available consisting of individual filaments having 0·0004 in. diameter. It contains about 2 per cent by weight of organic sizing compound, which is essentially a starch and oil type binding and lubricating agent. This binder can be removed by subsequent heat treatment at 340 deg. C.

The tensile strength of this yarn at room temperature is about 100,000 p.s.i. and at 980 deg. C., 15,000 p.s.i., while its elongation at break approaches 3 per cent.

CHEMICAL PROPERTIES—The resistance of fused silica yarn to alkali and acids is similar to that of glass E yarns. It is inert to all acids except hydrofluoric and hot phosphoric. It dissolves, however, in strong alkali. The properties of fused yarn and glass E are compared in Table 2. In addition to yarn, G.E.C. is also producing quartz mats which are usually supplied without a binder.

APPLICATIONS—This new type of inorganic textile material is currently evaluated in several high-temperature insulations, in filters, heat-resistant structural forms for machinery construction and in reinforced plastics.

It has been reported that Haveg Industries Inc.[23] is now moulding a combination of pure fused silica (quartz) fibres and thermosetting plastics resins into missile parts. Haveg's fused silica reinforced plastics are marketed under the trade-name Planeton Q. It has been claimed[23] that, in missile applications where fused silica-reinforced plastics replace metal, there is a potential weight reduction of more than 10:1.

Metal-coated Fused Silica Filaments

In the past few years numerous methods have been developed for the metal coating of glass yarns.[24–26] In a vapour deposition process patented by Owens-Corning Fiberglas Corp., the glass fibre yarn is continuously coated as it emerges from the bushing in a molten state by vapour deposition of such metals as nickel, iron, molybdenum, zirconium, etc. The same apparatus has been also proposed for applying the coating material by a gaseous plating process.[27]

Recently Bjorksten Research Laboratories have developed a continuous process for drawing fused silica filaments 20 micron thick and simultaneously coating them with aluminium or other metals. These fibres are characterised by a phenomenal strength reaching already 400,000 p.s.i.

TABLE 1. Compressibility of Micro-Quartz fibres

Compression lb./sq. ft.	% Decrease in Thickness		
	Under Load	Immediately after Removal of Load	16 Hours after Removal of Load
5	5·0	2·0	1·0
10	9·0	4·0	1·5
25	18·0	8·0	3·0
50	30·5	11·0	5·0
100	43·0	15·0	6·0

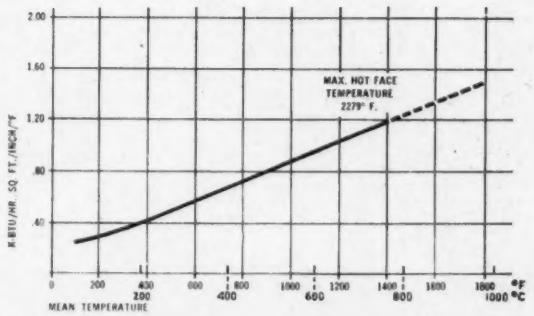
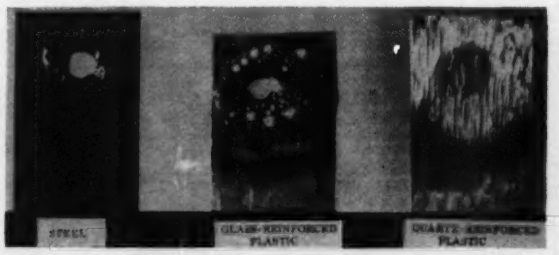


Fig. 1. Insulating properties or Micro-Quartz fibres.



A hot flame of more than 2,750 deg. C. melted and burned through a steel panel (left) and glass-reinforced plastics panel (centre) in less than 40 sec. Quartz-reinforced plastics panel (right) withstood the flame and retained its structural strength after exposure for 40 sec.

This combination of fused silica felt and high-temperature aluminium tape is used where parts are too small for moulded or shaped insulation.

These highly heat-resistant fibres can, in fact, be coated with almost any metal and be matted into a structural part. It has been reported that the U.S. Air Force Office of Scientific Research is considering using them in air-frames.[28] They may also find use in the electronics field as insulators and dielectrics, while the aluminium-coated fibres could be used for the manufacture of extremely strong and heat-resistant protective clothing.

TABLE 2. Properties of fused silica yarn and glass E.

	Clear fused Quartz	Typical Glass E
Density, gm/cc.	2·20	2·53
Young's Modulus, p.s.i.	10×10^6	$12{\cdot}7 \times 10^6$
Average coefficient of thermal expansion, 1/°C., 0–300°C.	$0{\cdot}55 \times 10^{-6}$	$4{\cdot}2 \times 10^{-6}$
Softening point, °C.	1,667	915
Annealing point, °C.	1,140	720
Strain point, °C.	1,070	675
Dielectric constant/Mc., 20°C.	3·78	6·3
Power factor/Mc., 20°C.	0·0002	0·0037
Loss factor/Mc., 20°C.	0·0009	0·023
Index of refraction, (Sod. D)	1·458	1·534
Thermal conductivity at 0°C., g.cal./cm.²/sec./°C./cm.	0·0033	
True specific heat at 0°C., g.cal./g.-°C.	0·165	0·170

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DEVELOPING METAL FIBRE-REINFORCED CERAMICS

IT has been predicted that within a relatively short time it will be difficult, if not impossible, to solve some of the high-temperature materials problems faced in the design of hypersonic missiles and aircraft without resorting to the use of ceramic materials.

Ceramic materials are not inherently good structural materials for use as components which require high mechanical strength, although there have been several electronic applications where they have been successfully manufactured for use under severe conditions. The possibility of using ceramics combined with metals to form composite materials has, however, been recognised for some years.

In the development of fibre-ceramic materials for application in the temperature range above 1,093 deg. C. the metal phase is limited either to the refractory metals, such as niobium, molybdenum, tantalum or tungsten, or the noble metals. High cost eliminates the noble metals from consideration, except in model systems for research purposes.

The forming and firing of ceramic oxides containing metal fibre present a rather complex problem. In forming, the fibre must be maintained in a uniform dispersion. Orientation of the fibre may be encouraged or discouraged according to whether or not uniform properties are desired in all geometric directions. In practice, it is almost impossible to prevent orientation of the fibres in forming. Orientation of metal fibres in one direction obviously increases the thermal conductivity in that direction.

The relative thermal expansions of the metal and the ceramic are much more important to the final results in metal fibre ceramics than in typical powder metal-ceramic cermets. In the thoria-molybdenum system the thoria has a much higher thermal expansion than the molybdenum. When such compacts were cooled to room temperature the thermal contraction of the thoria far exceeded that of the molybdenum and a system of cracks developed. The alumina and zirconia systems are similar to this in that the ceramics have a higher thermal expansion than the molybdenum. Cracks also developed in the alumina-molybdenum fibre system on cooling following firing, but these, as would be expected, were not as frequent or as large as those observed in the thoria-molybdenum system.

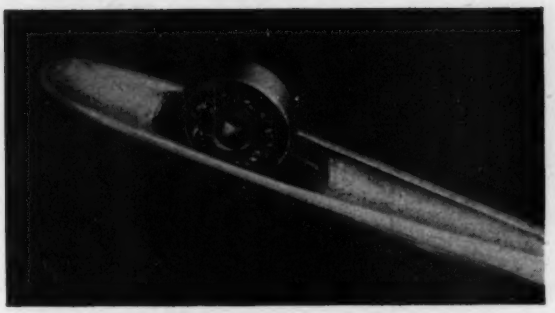
Systems of the type in which the ceramic either matches the thermal expansion of the metal fibre, or is less than the thermal expansion of the fibre, are to be investigated in future work at the College of Ceramics in New York.

The nature of the bond between the metal and the ceramic is also of interest. A chemical bond would be desirable, but too much reaction would be obviously disastrous. It has been indicated that a chemical bond exists between molybdenum and alumina mixtures formed at high temperatures, with the formation of a small, controlled amount of metal oxide which reacts with the alumina.

The principal difficulty in the forming and firing of ceramic-metal fibre lies in the fact that the metal fibre does not shrink during forming or firing, while the ceramic powder must shrink, particularly during sintering. The metal fibres oppose both forming pressures and sintering. Because of this, hot pressing was the obvious method to use for the fabrication of metal fibre-ceramics. But hot pressing, at least in most laboratories, permits the use of only a few simple small shapes.

In metal fibre reinforced ceramics, in which the thermal expansion of the ceramic was considerably higher than that of the metal fibre, cracks developed which decreased the strength of the compact in the fibre addition range from 5-20 wt. per cent at temperatures ranging from −85°F to 2,000°F. There was some evidence that metal fibre did increase the resistance of the composite body to failure by thermal endurance cycling, as it was observed by measuring flexural strength and modulus of elasticity. Impact resistance was decreased appreciably by the addition of 0·002 in. dia. × $\frac{1}{4}$ in. long metal fibres. This might not be true if longer fibres were used.

MINIATURISATION— A NEW TECHNOLOGY



The word "miniaturisation" has yet to be accepted by standard dictionaries, but the ability to increase capacity but not the size, or decrease the size while maintaining the capacity, is now a key factor in modern industry

ENGINEERING design often takes the form of building products larger or smaller than anything previously attempted, but in recent years miniaturisation has become a science with its own technology.

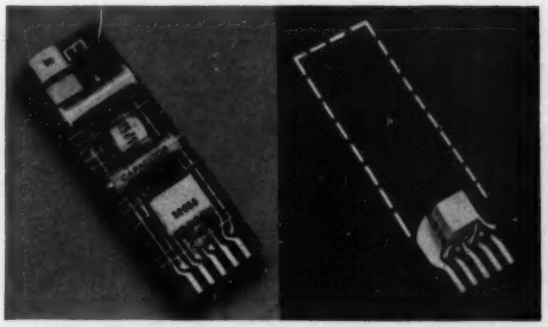
The effect of miniaturisation is widely felt: for example, the tiny bearings that help to make modern dental drills less painful may have a counterpart in the inter-continental ballistic missile; the executive's dictating machine uses a microscopic component employed also in a complicated aiming mechanism of a rocket-firing warship. From egg graders to vending machines, from artificial limbs to electronic computers, miniaturisation is now an important part of engineering design.

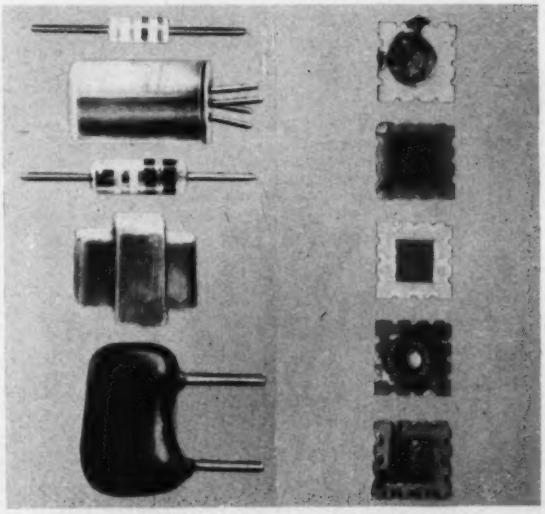
The main consideration behind miniaturisation has been the need to save space and weight; these have brought the problems of higher temperatures and working pressures. The desire to save space is not so much an end in itself, but stems from the increasing complexity of apparatus which require more components without an increase in space. Scaling down original designs is worth while for its own sake, but this is only a part of the story.

The rapid progress in materials technology has given impetus to the production of smaller components, and it is fair to say that without it no miniaturisation would have been possible. While new materials play their part, there has been considerable emphasis on the production of existing materials to a degree of purity hitherto obtainable only under laboratory conditions. Zone refining, vacuum melting and electron beam melting are but a few of the techniques involved.

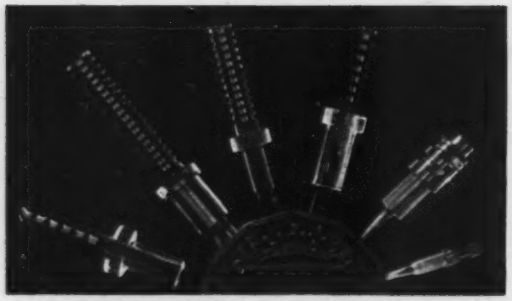
To produce these miniature components, machines have to be designed on an entirely new basis. The reduced mass of an article may not, for example, lend itself to the same treatment as a greater mass. For instance, in fusing or melting a material, it may be necessary to use a container; if the mass is small enough, it is possible that surface tension may enable the container to be eliminated, but this does not necessarily make the machine simpler.

Fits and tolerance are another important aspect, for smaller components must have a corresponding reduction in limits in manufacture, indicating that machine tools must be made to even finer limits than normally, in order to produce miniaturised components. An example of this are ball bearings made to an extremely high degree of precision and which are not only for producing miniature components, but themselves are miniaturised and used in components.



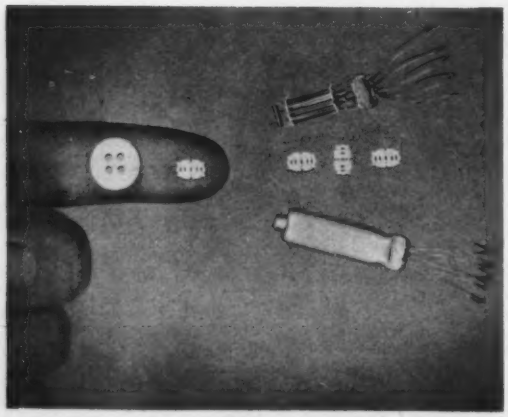


R.C.A. has developed a modular system for miniaturised electronic components. On to Micro-elements (tiny ceramic wafers 3/10 in. sq. and 1/100 in. thick) are fused conducting, semiconductor and insulating materials to provide electrical characteristics of resistors, capacitors, transistors, etc. These are interconnected and encapsulated to form what R.C.A. call Micro-modules. Top picture shows the effect on a pulse generator, comparing conventional and Micro-module plug-in units. Below are other conventional components compared with Micro-element versions.

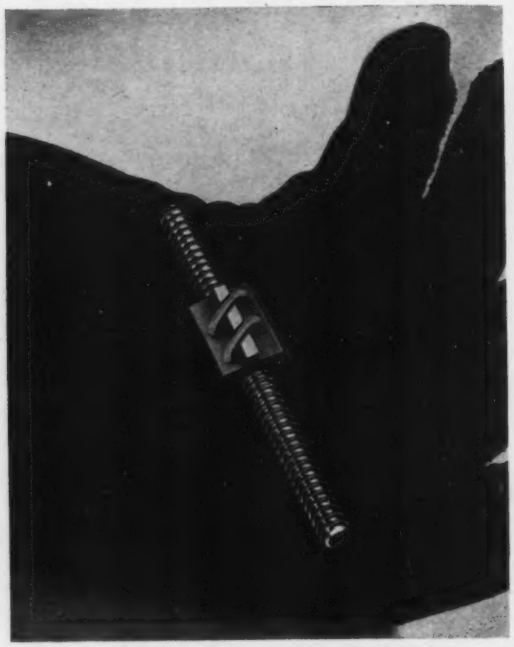


▲ A selection of miniature cylindrical slip rings made by I.D.M. Electronics Ltd. with Araldite epoxy resin insulation.

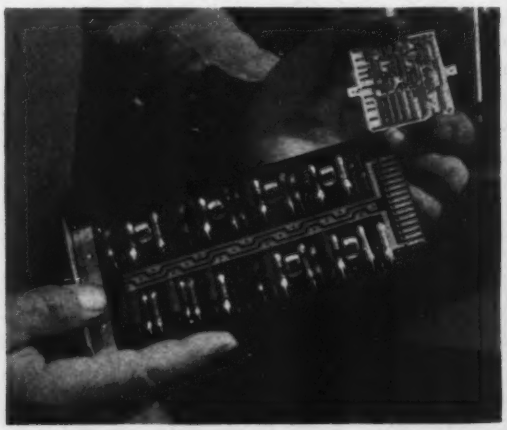
▲ This computing unit (shown compared with a cigarette) is a passive non-linear device produced by Douglas Aircraft Co. for dealing with unusual mathematical factors: it provides about 25 of the most basic and commonly used non-linear functions. Most natural laws are non-linear in some way and mechanical devices have imperfections and inherent non-linearities, while mathematical methods tend to favour the analysis and solutions of linear problems. There is a tendency to ignore non-linearities such as friction and elasticity, but recent advances have forced a change in this attitude so that more non-linearities have to be considered to represent realistic situations more faithfully. With the Quadratron, approximations to useful functions can be obtained, such as $(ax^2 + bx)^{1.43}$.



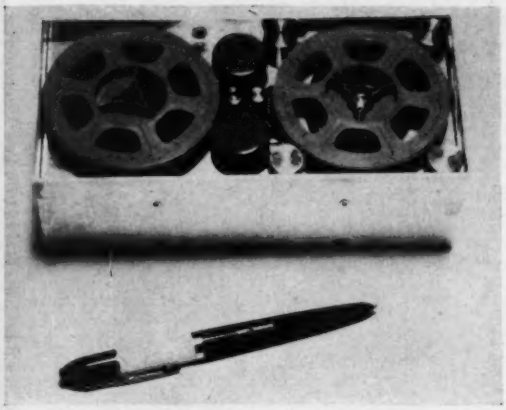
▼ The recirculating ball and nut is a modern method of reducing friction. This is claimed by the makers, General Motors' Saginaw division, to be the smallest ball-screw ever, yet it can position components to within 0·0005 in. for each inch of travel, and will operate at 80 per cent efficiency in temperatures as low as −54 deg. C. At room temperature, efficiency is nearer 95 per cent, and is thus suited to conversion of rotary to linear motion.



▼ Comparison of reduced size of a printed circuit using sputtered resistors developed by Bell Telephone with a comparable conventional printed-circuit board. The small ceramic circuit card contains sputtered capacitors and connecting leads, as well as resistors, thus incorporating all the components of the larger board except the diodes, which can be attached by dip-soldering.

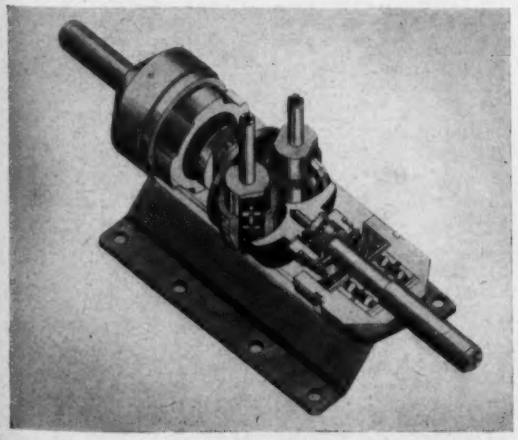


◀ For the Raytheon tube used in guided missiles and tiny walkie-talkie sets, these mica tube spacers are production stamped to 0·001 in. tolerance. Tube itself measures 0·375 × 1·5 in., withstands higher temperatures and electrical loads than preceding types and it can also withstand impact and acceleration shock. Spacers are made by Ford Radio & Mica Corp.



▲ When Miniature Precision Bearings Inc. recently sponsored awards for worth-while miniaturisation, this 3½-lb. tape recorder design by K. O. Johnson, of Stanford University, Cal., was one of the winners. It measures 6½ × 3 × 2 in. and will record and play back from 30-8,000 c/s for 30 min. from a 3-in.-diameter roll of tape. A miniature three-phase synchronous motor is driven by a 60-cycle transistorised power supply servoed from the capstan flywheel. Self-contained batteries are said to last 90 hr. In the U.K., the Fi-cord (below) is a miniature recorder operating from rechargeable batteries.

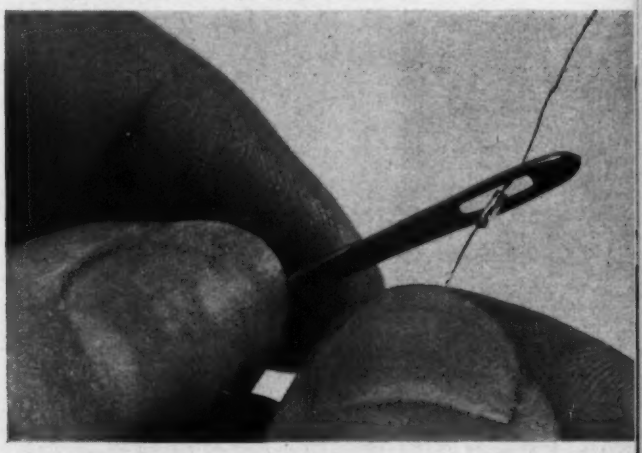
▼ Miniaturisation in mechanical devices is seen here applied to an infinitely variable speed unit. The Metron, made by Metron Instrument Co., indicates the general principles, which consist of a metallic friction drive with a loading mechanism to increase the pressure in proportion to the torque.



▼ This new type of cockpit instrument panel was developed by the U.S. Army-Navy Instrumentation Programme. It enables the pilot to fly along a predetermined pathway shown on a screen. Picture and pathway displayed are produced aboard the aircraft by a sub-miniaturised computer and electronic system.

▼ This 1-in.-long gearhead that will produce a 6,000:1 reduction ratio is shown alongside a larger version that used to do the same job in jet guidance systems. Miniaturisation began in mechanical engineering later than in electronics; miniature gears have to be cut to tolerances finer than in precision watches (2/10,000 in.) and ratios must in some instances be increased to three million to one. A speck of dust could clog a gear of this sort.

▼ The body of this Sylvania incandescent lamp has a length of 0·125 in.—small enough to pass through the eye of a needle. Called the Mite-T-Lite, it can operate from the limited power available in most transistorised circuits. Its output is some 180 millilumens at 1·5 volts input—an efficiency of about 3 lumens per watt. Its light can be easily seen in a normally-lit room at all points even when operating at 1·0 volt.



NEW IDEAS IN DESIGN

Outstanding products in current manufacture

A Glandless Coaxial Domestic Circulating Pump

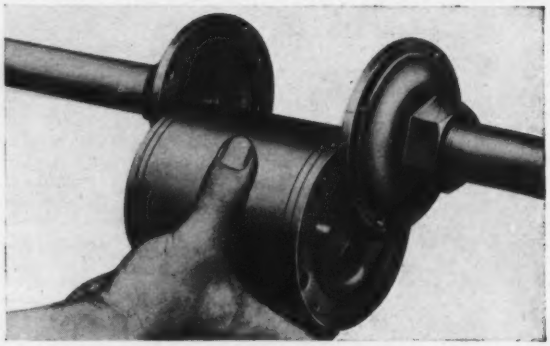
THE Daxel Mopump recently developed by Rhodes, Brydon & Youatt Ltd. is a small centrifugal pump of compact design having obvious advantages from the standpoints of installation and serviceability, as can be seen from the accompanying photograph. Both ends of the Daxel screw directly into the pipework and there are no flanges or feet to be bolted up.

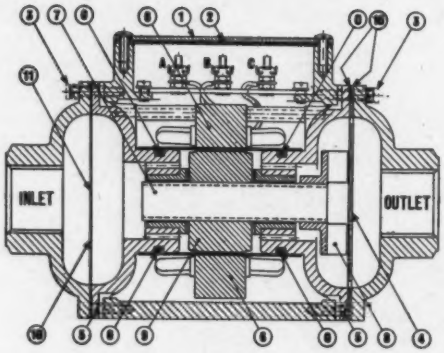
The straight-bladed impeller, which can operate in either direction of rotation, is fitted to one end of the stainless-steel tubular shaft to which the rotor is fitted. This shaft runs in Ferrobestos bearings. A filter is fitted as an integral part of the pump; this is on the inlet side and so filters all the water before it enters the pump, thus protecting the working parts. Water is prevented from entering the field coil region by a non-magnetic stainless-steel sleeve which is sealed by O-rings. On the outlet side water passes from the casing through slots in the delivery diaphragm (4) to the outlet branch.

Apart from the commendably neat appearance, the pump is claimed to be practically vibrationless in that any electrical vibration in the motor unit is absorbed by torsional oscillation of the unit, and not by a separate pump mounting.

The Daxel is screwed 1 in. B.S.P., but is stated to be easily adaptable for other sizes. Standard motors are for 200/220 or 230/250 volts supply, 50 cycles, single-phase, but motors with alternative voltages can be supplied. The pump delivers 2-8 gal./min. against 8-1½ ft. head. It is said to be suitable for static pressures up to 25 p.s.i. and water temperatures up to 80 deg. C.

It is claimed that the Daxel Mopump is the smallest circulator of its type on the market, measuring 4½ in. dia. by 8½ in. overall. The weight of the whole unit is 15½ lb.



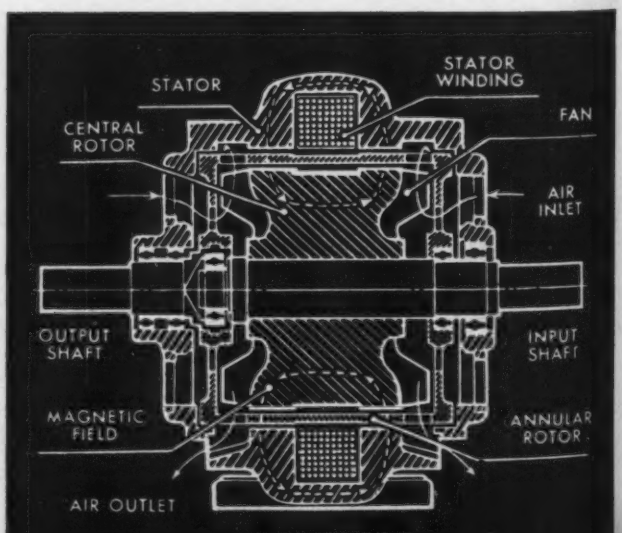


New Speed Regulator Uses Eddy Currents

THE Elcotron, recently introduced by Westool Ltd., is a new type of speed regulator intended for use as a coupling, a clutch and a torque limiter and controller and can be remotely or directly controlled. It is said already to have been successfully applied to coil winding machines, printing machines, winches and mine cages. Other applications are being studied.

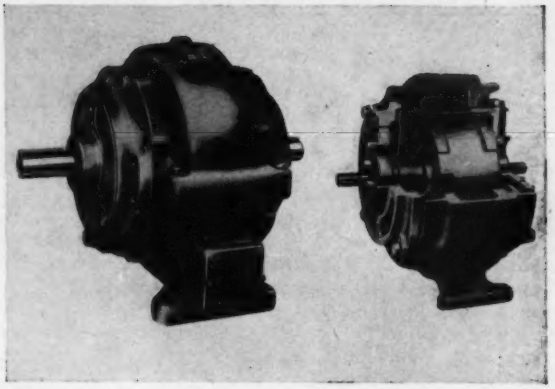
It comprises a stator with a stationary field coil in which rotates an annular rotor and a central rotor, the latter being driven by a prime mover, the former being attached to the driven load. When there is no current flowing in the field winding, the input shaft and rotor run idle, while the annular rotor coupled to the output shaft remains stationary. When direct current is fed into the field winding a magnetic field is created which causes the annular rotor and the output shaft to rotate. The speed of the latter depends on the exciting current in the winding and on the torque to be supplied.

The manufacturers consider that the Elcotron is ideally suited for remote control applications, as the wattage controlling the excitation of the regulator is only a fraction of the h.p. that can be transmitted, e.g., 1 kW. can handle a transmitted power of 200 h.p. The speed of the Elcotron can be infinitely varied from zero to just below the speed of the driving motor by using it in conjunction with a fixed-speed squirrel-cage induction motor. Both the



output speeds and torque can be held automatically constant at any desired level irrespective of load changes. It is stated that output torque can also be governed at a pre-set value and no overload can be transmitted through the regulator to the prime mover.

It is considered particularly suitable for applications where problems of load sharing and synchronisation occur. For example, where it is required to drive one machine from two or more motors, a regulator can be fitted to each motor and controlled so that the driving motors always supply equal power to one machine. This avoids undue stress on one particular driving motor. Alternatively, on conveyor systems, where two or more motors are used, each motor can be equipped with a regulator and automatically synchronised to give constant conveyor speed throughout the system.

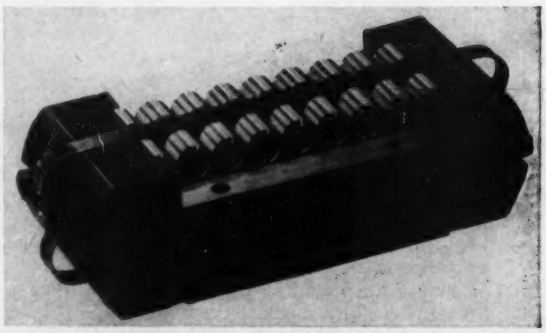


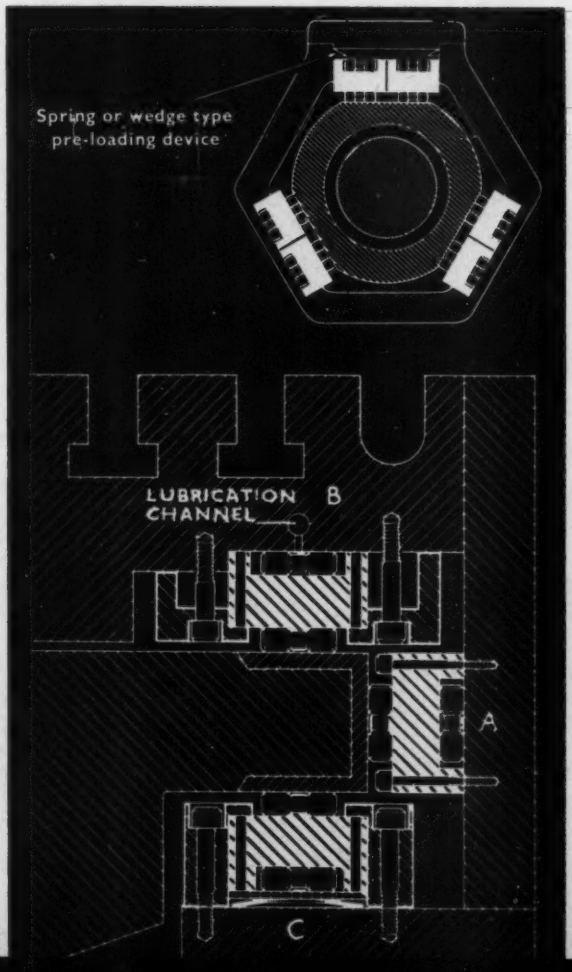
Recirculating Roller Linear Bearings

NOW manufactured in this country by Rotax Ltd., the Tychoway bearing is claimed to conform to the exacting requirements of machine tool manufacturers for use in machines requiring a high degree of linear positioning accuracy, very low friction, long accuracy life, etc. The presence of a return channel for the rollers within the bearing itself is said to facilitate accurate assembly directly to a precision machined flat surface and so eliminate the need for hand fitting of the slides. Centre-guided rollers are used to eliminate the usual problem of skewing encountered in roller ways. The accompanying sectional drawings show four convenient means of mounting. Those marked A, B, and C in the lower view indicate applications to machine tool slideways. A takes advantage of the mounting holes provided in the race of the bearing. This method is used for normal load operation. In heavy load applications, where recommended loads may be exceeded, it would be preferable to use a method similar to B. A pair of clamps are used in B equal to the race in length. The clamps, secured by cap screws, seat on the race rolling surface and the machine mounting surface. It is stated that very high clamping forces can be obtained by this method. At C a means of spring loading with Belleville spring washers is shown. Spring loading is used in conjunction with an opposed fixed bearing to give a pre-loaded assembly. This is claimed to eliminate the need for upper and lower surface parallelism required in ordinary gib design. The smaller sectional drawing (*right, above*) shows the application of Tychoway bearings to a quill tube. The use of rollers in this type of assembly allows for a fixed or variable means of pre-load with virtually no deflection of the quill. In this novel design it is claimed that the re-circulating roller feature allows unlimited quill travel with high "retracted" rigidity.

Although Tychoway bearings are said not to require an oil film for their anti-friction characteristics, a standard type of oil or grease can be used, depending on the application. For slow, intermittently operated and relatively clean assemblies, the bearings can be packed with a good grade of non-oxidising grease without means of relubrication. But it is stated that bearings used in this manner should be well sealed to retain the lubricant. For periodic or continuous lubrication the manufacturers recommend that a lubrication channel to the centre of the bearing be provided as at B.

Sealing requirements closely parallel those of radial anti-friction bearings and the same general rules apply, standard way wipers and bellows being available from various manufacturers. For these bearings it is considered that sealing foreign matter out is generally more important than sealing the lubricant in, owing to the ease of relubrication.





Revolutionary Blade-type Blower

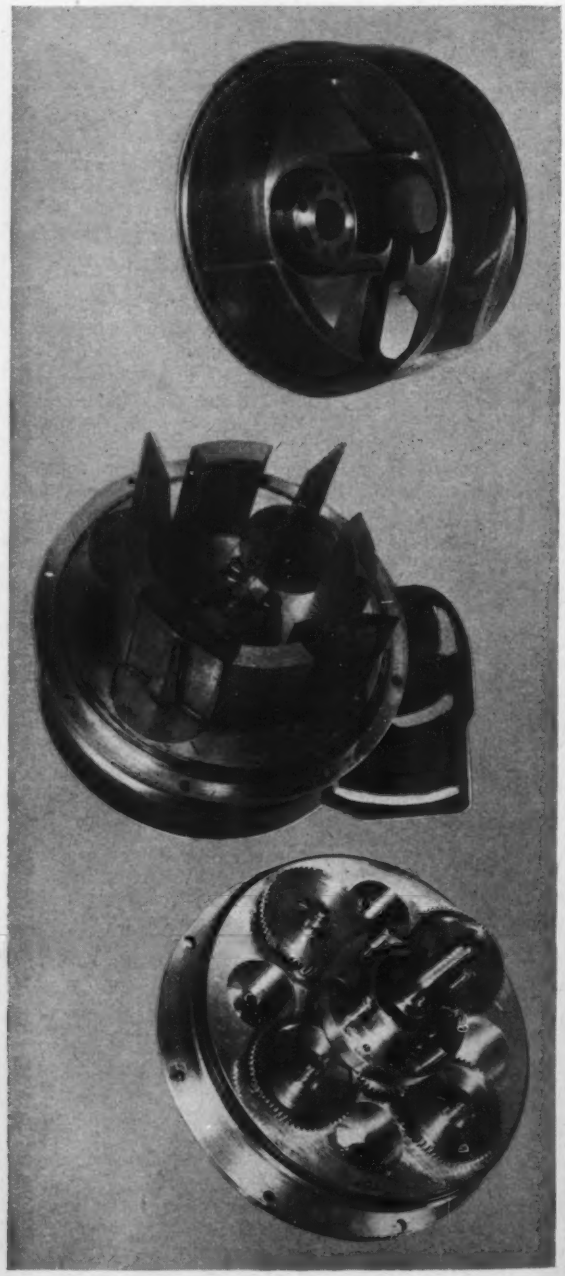
A STUDY of the shortcomings of the Roots-type blower has led to the development by B.I.C.E.R.A of a blade-type blower of a form which, it is claimed, could be developed for any size of engine. Although the experimental blower was made specifically for low-pressure charging of a four-stroke-cycle engine it is considered eminently suitable for supplying the scavenge air for two-stroke-cycle engines. The object of the invention was to obtain continuous inlet and delivery processes at constant velocity and having efficient compression characteristics.

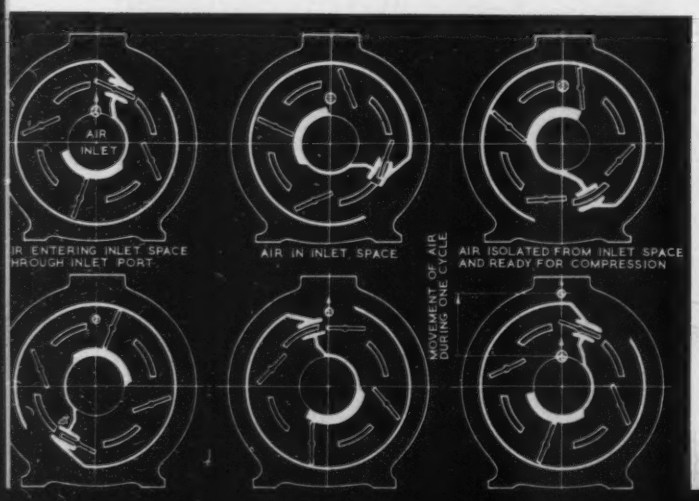
Air intake, compression and delivery take place in an annular channel formed in a rotor. This channel is divided at all times by a moving barrier through which the rotating blades pass and, at 180 deg. to this barrier, by each of the blades in turn which, at this position, are radial to the axis of the rotor. When positioned in this way across the annular rotor channel the blade forms a blockage so that the revolving of the constriction acts as a piston, causing an increase in channel volume on the one side and a decrease on the other which give intake and delivery through ports in the walls of the channel. Before the revolving piston reaches the blade, the latter has turned through 90 deg. so that it is capable of passing through a narrow slot in the piston as it passes over the blade. The movement of a particle of air through the blower during one revolution of the blower is shown in the diagram below.

The blades are mounted on shafts which rotate in a back plate which also supports the blade spacing pieces. A gear train giving a 2:1 reduction in speed drives the blades and keeps them in phase with the rotor, which is driven directly by the main shaft. This shaft transmits all the power required for the compression process, leaving the blades free to rotate without doing work on the air. On the small prototype machine the blades are over-hung from their supporting shafts, but on larger machines it would be possible to insert bearings at the remote ends of the blades, thereby permitting a greater ratio of blade length to diameter to be used.

The experimental blade-type blower shown, which has no internal pressure, but rather displaces air, was designed for relatively low pressures, the first target being 5 p.s.i.g. at 4,500 r.p.m. This gave a rotor having a rim velocity of 160 ft./sec. and a mid-channel velocity of about 100 ft./sec.

Some outstanding design and manufacturing advantages for this type of blower are claimed. Fine clearances are said to be not necessary, the sealing faces between the rotor and the casing requiring only simple turning, and the blades have a degree of freedom to rock on their own axes as the slot passes over them without the seal being broken or the tips fouling. With the air passing through constant areas of port and channel, there is little throttling loss, the method of air displacement being comparable to a normal piston compressor with both the inlet and delivery ports equal in area to the whole of the cylinder head. In addition, there is some centrifugal assistance from the rotor to the air as it passes from the central inlet radially towards the outlet port. Those components that carry out the compression process do not need lubrication and the only friction losses are those from the bearings and gears and, as the loadings on these are light, a relatively inexpensive gear train can be used.




AIR INLET
AIR ENTERING INLET SPACE THROUGH INLET PORT
AIR IN INLET SPACE
AIR ISOLATED FROM INLET SPACE AND READY FOR COMPRESSION
MOVEMENT OF AIR DURING ONE CYCLE

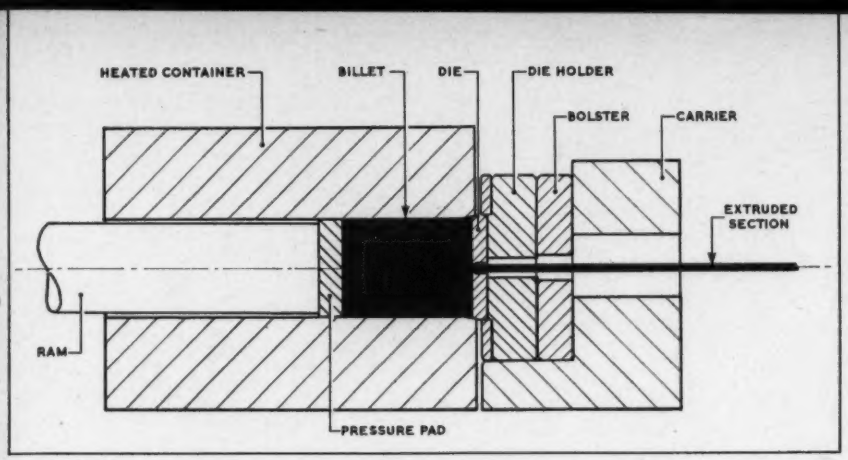


Diagram showing principles of extrusion technique.

HOW THE DESIGNER CAN USE EXTRUSIONS

An almost limitless range of shapes in the form of aluminium extrusions can be produced to simplify the work of the designer today. Their varied application in various industries is described in this article

by T. E. G. MUNRO, A.S.M.A.*

THE increasing use of aluminium alloy extrusions in a wide variety of fields is largely due to the infinite range of shapes that can be produced; other advantages include lightness, high corrosion resistance, good mechanical properties and low maintenance costs. Shipbuilding, commercial vehicle bodies, bridges, metal windows and textile machinery are but a few of the many applications in which designers have successfully used extrusions.

The process of manufacturing an extrusion is performed on a hydraulic press and consists of forcing a heated aluminium billet through an orifice in a steel die. Solid sections of almost any shape can be produced by making the die-orifice the shape of the section desired, while special die techniques allow the production of hollow sections and tubes.

Unless the demand is very small, it is usually more economical to design a section to suit the particular functional requirements rather than to adapt an existing or standard section. The following examples are intended to assist the designer in exploring the various methods whereby the technique can be applied to his own needs.

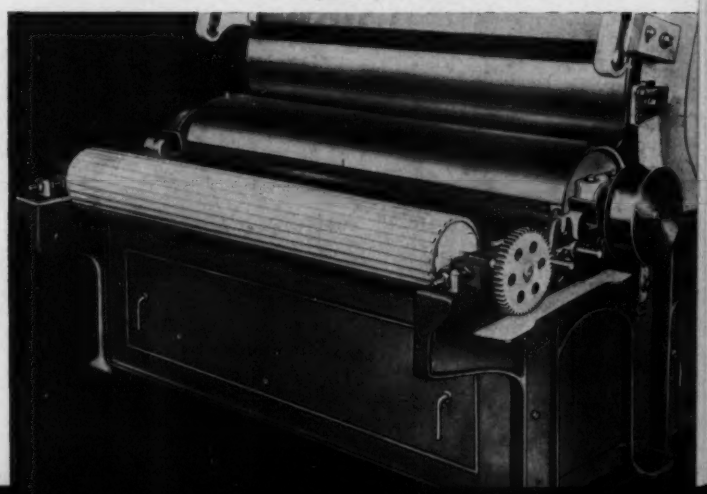
Where plain structural members are in compression and are prone to local or torsional instability, it is an easy matter in the extrusion process to add bulbs or lips to outstanding flanges in order to increase their ability to withstand such types of failure. This is more economical than increasing the thickness of the whole of the flanges in order to produce the same result. Fig. 1 illustrates a channel section treated in this manner. Where a stiffened sheet is required, instead of attaching stiffeners by riveting or welding, the same effect can be produced far more satisfactorily by extruding an integrally stiffened sheet as shown in Fig. 2.

Almost unlimited scope is offered when deciding on the cross-sectional shape most likely to assist the functional purpose of the extrusion. Additions of ribs, lugs, flanges

* *Southern Forge Ltd.*

Fire tender built by Alfred Miles Ltd., showing the use of roller shutters embodying aluminium extruded sections.

Application of aluminium extrusions in the textile industry is typified in this Platt Bros. lap roller, seen here in position on a partially erected cotton card.



and re-entrant features can be effected more economically than by rolling. Indeed, many such features cannot be produced by rolling. This is illustrated in the commercial vehicle interlocking floor plank in Fig. 2. The interlocking feature prevents the planks deflecting independently when under load, while the ribs on the top assist in protecting the surface from abrasion. The legs which rest on the cross-bearer of the vehicle are placed so that maximum strength is obtained.

The ability of the extrusion process to permit variations in thickness in the same cross-section allows a designer to "tailor make" the extrusion exactly to fit his particular requirements. The roof glazing bar (Fig. 3) is a good example of this. Each part of this extrusion is designed to perform its task of adding strength, supporting and sealing the glass or acting as a water gutter in the most efficient manner.

This facility is further illustrated by the bar and socket type of interlocking section, exemplified by the roller shutter lath in Fig. 14 and the caravan window hinge in Fig. 10.

It is often necessary to combine several rolled sections into a single member either by riveting or welding, in order to obtain the desired shape. This involves "doubling up" in metal thickness, which, unless structurally desirable, is expensive. In most cases such an assembly of rolled sections can be replaced by a single extrusion. Not only does this effect a saving in fabrication costs and a more efficient use of metal, but the resultant member is stronger because of its homogeneous nature, and the possibility of rivet or weld failure is eliminated. Figs. 4 and 5 are simple examples of this technique.

However, there will be applications where an assembly of sections on the "trunking" principle is needed in order to conceal wires, connecting rods, etc., or to conceal or eliminate unsightly screws and bolt heads by the use of interlocking sections. These may be provided with integral fixing arrangements in the form of a dovetail or snap or sliding fits. Examples are shown in Figs. 11 and 12.

The "bridge mandrel" technique makes possible the production of complex hollow extrusions. Although the manufacturing cost is higher than that of solid extrusions, the elimination or reduction of subsequent fabrication usually produces a more economical end-product. One example is the heat-exchanger in Fig. 6, in which the fins are an integral part of the tube, thus increasing the heat-transference efficiency. Another is the post section (Fig. 7) used in the construction of office partitioning. Other examples of this principle can be seen in Figs. 8 and 9.

Aluminium alloys possess good machinability; indeed, there are special alloys which have the same machining characteristics as those obtained from free-machining brass. In addition, the close dimensional tolerances to which extrusions are made often reduce machining or eliminate it altogether. The machining of longitudinal projections, steps and recesses is not necessary, since these features can be incorporated in the original extrusion design. The textile lap roller (Fig. 9) is a good example of the elimination of a costly machining operation by the use of an extruded fluted tube produced to close limits.

Small components that are normally cast or machined from the solid can often be made much cheaper by parting-off an extrusion in the cross-sectional plane. Hinges, as shown in Fig. 13, and the barrels and sleeves of door bolts (Fig. 8) are common examples of this technique.

The clean appearance of aluminium extrusions is an advantage to designers who are concerned both with decorative appeal and also the structural function of a section. The normal corrosion resistance of aluminium can be improved by anodic treatment. Since the anodic film can be dyed with a variety of colours, the decorative value of the sections can be considerably enhanced.

NEW PRODUCTION TECHNIQUE COMBINES

SPECTACULAR reductions in the number of operations needed to produce long cylindrical vessels and other components are claimed possible with a new technique just introduced by Lodge & Shipley Ltd. The method, called Multi-Flo-Reforming, is essentially a development of flow forming, but with rather more dramatic results. Great economies in tooling may be made and the number of actual operations needed may be cut to about a third of that needed to produce the component by deep drawing.

Fig. 3 shows the number of stages (exclusive of washing, trimming and annealing) required to produce the stainless-steel cylindrical shell shown, which measured 14 in. high, 2¼ in. dia. and 0·045 in. wall thickness. The total number of operations to produce the vessel, including washing, annealing, etc., was ten. The manufacturers consider that were such a component able to be manufactured by deep drawing, approximately twenty-eight individual operations would be required. Apart from saving two-thirds of the operations, other economy factors would include savings in material, capital equipment, tooling, etc. Finish and mechanical properties are claimed to be far superior to deep-drawn components.

The process employs two manufacturing processes, flow forming (which this company calls Floturning) and press work. In the case of the cylindrical vessel shown, the flat blank is first sheared to size. It is then flow formed to the conical shape shown and then washed, annealed and trimmed. Now it is ready for the first Reform operation, which converts the upper portion of the cone to straight-sided shape, but the diameter is still greater than that of the finished component. Reforming somewhat resembles forward extrusion in that the metal is displaced in the same direction as the press punch. As shown in Fig. 1, the Reforming tool set consists essentially of a punch which works into a two-part die. The outer die controls the forming operation, developing the finished cylindrical shape. The inner die holds the flow-formed blank and also guides the punch.

It will be seen that the right half of the drawing represents the condition at the beginning of the Reforming operation. The punch is bottomed in the blank, which is held in the outer die by minimum pressure on the inner die. Stop blocks on the inner die are set for zero clearance and the conical face of the inner die is relieved approximately 0·01 in. at

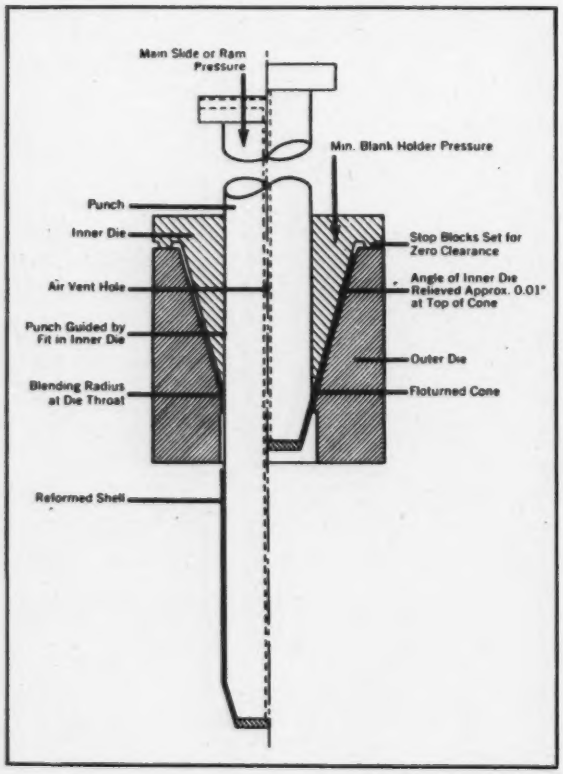

Main Slide or Ram Pressure
Min. Blank Holder Pressure
Punch
Inner Die
Air Vent Hole
Punch Guided by Fit in Inner Die
Blending Radius at Die Throat
Reformed Shell
Stop Blocks Set for Zero Clearance
Angle of Inner Die Relieved Approx. 0.01" at Top of Cone
Outer Die
Floturned Cone

Fig. 1. First reform stage. Upper portion of cone is converted to straight-side shape.

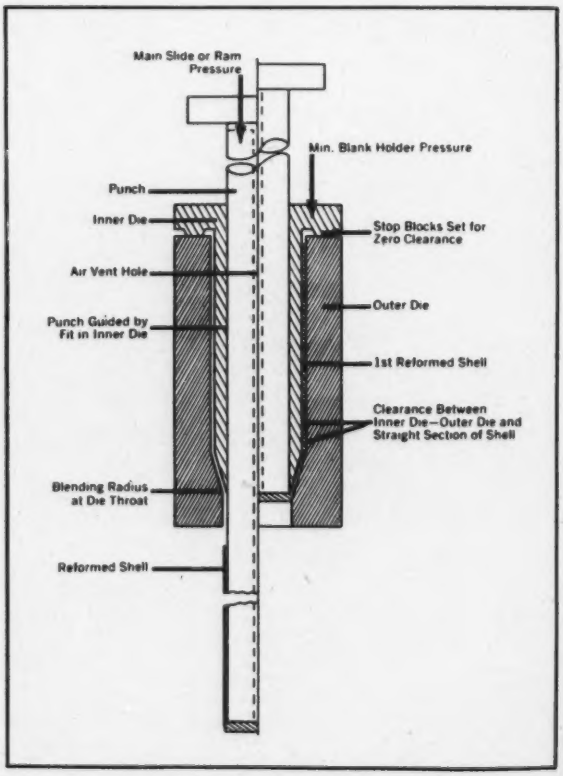

Main Slide or Ram Pressure
Min. Blank Holder Pressure
Punch
Inner Die
Air Vent Hole
Punch Guided by Fit in Inner Die
Blending Radius at Die Throat
Reformed Shell
Stop Blocks Set for Zero Clearance
Outer Die
1st Reformed Shell
Clearance Between Inner Die—Outer Die and Straight Section of Shell

Fig. 2. Second reform stage. After annealing, workpiece is brought to finished diameter and length.

FLOW FORMING AND PRESS WORK

the top of the cone. This minimum relief allows the cone to thicken as it is reduced in diameter and still supports the metal as it approaches the blending radius with zero clearance at the die throat. The left half of the first Reform illustration shows the tool set and the work-piece at the end of the operation. The flow-formed cone has been formed into a cylinder over most of its length. Only the small section at the lower end of the shell still has the conical form.

The second Reform tool set (Fig. 2) is made on the same lines as the first with allowances for the fact that the "blank" now has only a short conical nose section which must be Reformed to the final cylindrical shape while bringing the entire work-piece to the finished diameter. On the right side of the drawing is shown the blank at the beginning of the operation. The punch is bottomed in the blank which is held in the outer die by minimum pressure on the inner die. Stop blocks on the inner die are set for zero clearance. Clearance is provided between inner die and outer die and the straight section of the blank. The left half of the second Reform illustration shows the tool set and the work-piece at the end of the operation. The remaining conical section has been formed into a cylinder and the diameter of the workpiece has been reduced to the finished dimension.

A set of rules and formulæ has been devised by Lodge & Shipley from which, it is claimed, it is quickly possible to arrive at major and minor cone diameters, blank thickness and cone angle for the initial flow-formed cone. In addition, a Flo-Reform calculator, consisting of a family of graphs, enables the angle of the cone and its diameter to be related to the height of the reformed shell.

Unlike a deep-drawn shell, the base of a shell produced by the Multi-Flo-Reform process is the same thickness as that of the initial sheet metal blank. In cases where the gauge must be uniform, this can, of course, be reduced by turning. In some cases, however, this may be an advantage.

The process would appear to greatly extend the uses to which flow forming can be put, and to open up the field for new kinds of component hitherto impossible by ordinary deep drawing. In addition, work considered unsuitable for deep drawing, which would formerly have necessitated machining from the solid, would now appear to be possible.

A new-type Floturn machine at present being manufactured by C.V.A. Ltd., having template following control is illustrated in Fig. 4.

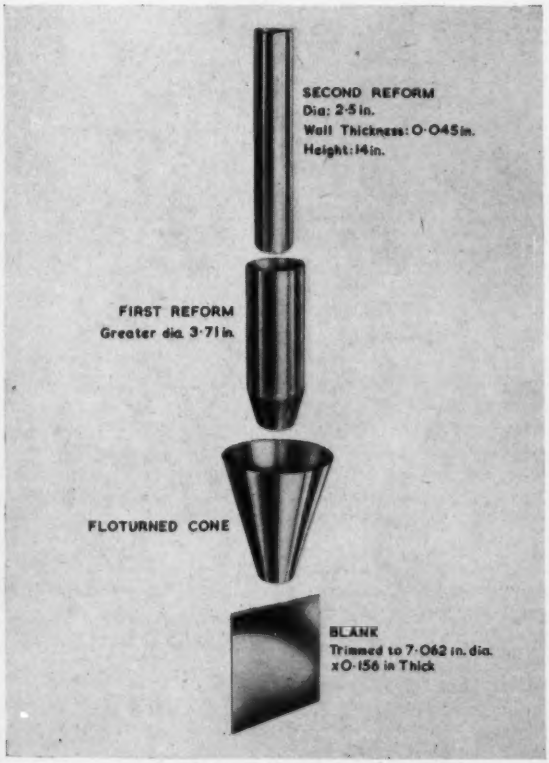


Fig. 3. Stages in the production of a cylindrical shell by one flow forming and two press operations.

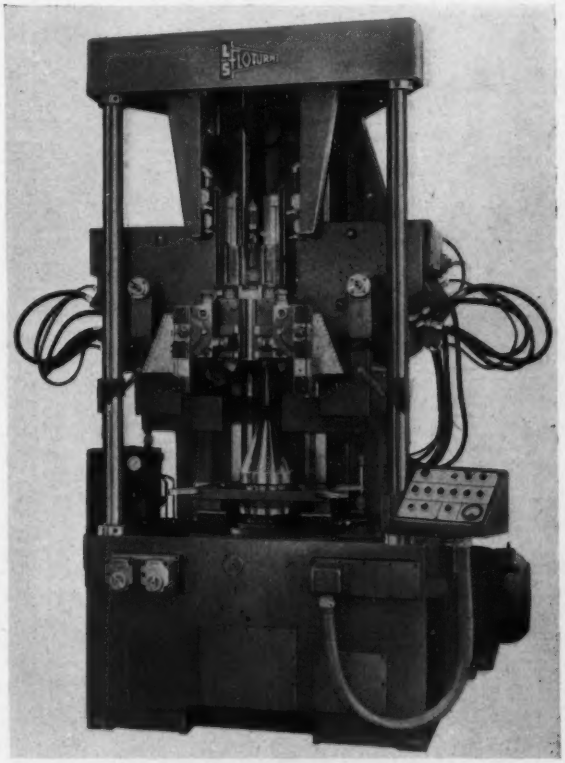


Fig. 4. Lodge & Shipley No. 12 Vertical Floturn machine for producing components up to 16 in. diameter.

MOLYBDENUM AND TUNGSTEN ALLOYS

This article reviews the developing uses of molybdenum and tungsten as metals and carbides, and discusses their value in applications where they can be used for tools and cutting edges

by E. J. SANDFORD, B.Sc., Ph.D., F.I.M. *

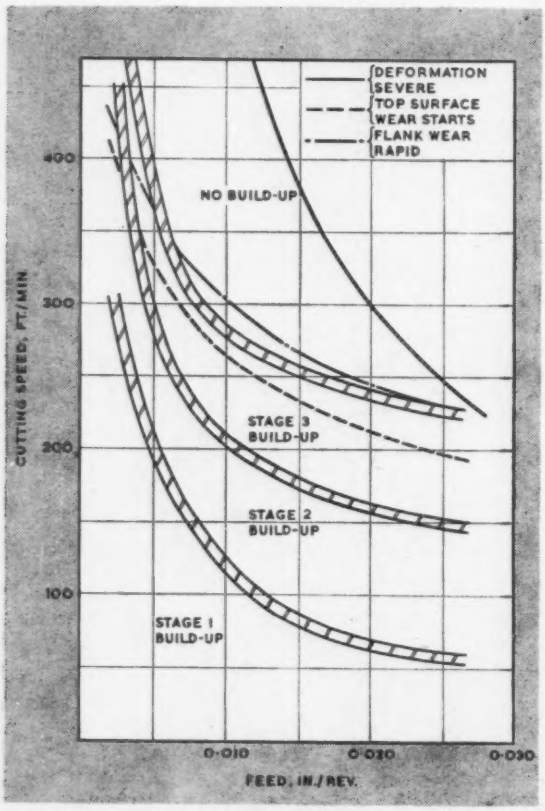


Fig. 1. Relationship between cutting speed, feed, build-up, etc. (according to Harding and Trent).

MAN'S earliest attempts to use metals were based on the powder metallurgist's art rather than the founder's, but when high enough temperatures were possible this clumsy method was given up and melting and casting took its place. The so-called refractory metals, molybdenum, tungsten, etc., continued to be examples of the science (and art) of powder metallurgy until the last decade. Now, molybdenum is being melted on a scale undreamed of twenty-five years ago. Nevertheless, powder metallurgy, which by the availability of higher temperatures might have become an historical curiosity, has in fact grown up in its own right and has taken its place as an essential metallurgical process. In this article some recent progress in casting and sintering will be reviewed.

Molybdenum

The unique properties of molybdenum made the production of larger pieces than is possible by powder metallurgy most desirable.

The Climax Molybdenum Co. U.S.A.,[1] are now casting it in vacuum arc furnaces by the consumable electrode technique. The furnace carries out continuous pressing, sintering and melting of molybdenum powder containing a controlled addition of carbon as a deoxidiser; crushed scrap turnings can be added.

The powder flows from a hopper into a split die on top of the previously pressed powder. As a hydraulically-operated punch presses the rod downwards it is sintered by being heated on three sides. An electrode is thus produced and sintered continuously.

The furnace proper is a water-cooled copper mould. To start melting, an arc is struck between the bottom of the electrode and some molybdenum in the bottom of the mould. As the electrode is consumed it is automatically fed downwards, while the ingot builds upwards. All this process,

* *Hard Metal Tools Ltd.*

pressing, sintering and melting, takes place in a high vacuum. The furnace shown gives ingots up to 4 ft. long, 9 in. in diameter and weighing 1,000 lb., but a larger one makes them 12 in. in diameter, weighing 2,000 lb.

Arc-cast molybdenum is nearly of theoretical density. It is particularly low in gas content, which is very important because oxygen reduces ductility. Unlike sintered ingots, it is coarsely crystalline and requires considerable mechanical working to make it of fine-grain size. The forging temperature is 1,200-1,300 deg. C. Only if deoxidation is complete is forging possible; molybdenum oxide in the structure inevitably causes cracking. According to Deuble,[3] rolling has not been very successful, and the best method of working has been extrusion, using the Ugine-Sejournet process.

Subsequent processing consists of cropping the ends, heating to recrystallise the structure, and machining the surface to remove defects. The bars are then hot rolled down to $\frac{1}{4}$ in., and finally swaged and hot drawn. Extruded bars can also be rolled to rectangular section, and, after recrystallisation, down to sheet. The sheet can be fabricated by most of the well-known techniques with, of course, greater difficulty than is experienced with the common alloys. These difficulties can be comprehended by remembering that steel at room temperature is equivalent to molybdenum at a much higher temperature. Fabrication temperatures are adjusted in accordance with the process and the final properties which are required. According to Deuble,[3] if properties are of no consequence, die forging is best done at 1,430-1,540 deg. C.; but for best mechanical properties at least 50 per cent reduction must be effected below the recrystallisation temperature, namely 930-1,040 deg. C.

The properties at room temperature depend so much on the mechanical and thermal treatment that it is useless giving figures, other than to say that tensile strengths of 30-50 t.s.i. with elongations of a few per cent to over 50 per cent can be obtained. Deuble[4] has discussed this subject fully.

There are four commercial alloys of molybdenum, containing respectively 0·3 per cent Nb, 0·5 per cent Ti, 1 per cent V, or 2 per cent W. The first three have better high-temperature strengths than pure molybdenum, and the last is more easily welded. Wrought molybdenum can be obtained with considerable ductility at room temperature by careful control of the grain-structure.

Olds and Rengstorff[5] found that the cold ductility of cast molybdenum is severely reduced by traces of oxygen. Brittleness at room temperature is caused by 1 or 2 parts per million. Nitrogen is somewhat less harmful and about 30 parts per million are necessary to cause brittleness. Carbon is even less harmful, and about 140 parts per million are required.

Tungsten and molybdenum are both refractory metals. They have high melting points, and therefore are at first sight attractive for high-temperature applications. Pugh[6] has shown that at a temperature of 50 per cent of the melting point, the tensile strength is nearly 10 t.s.i., which for tungsten is at 1,700 deg. C. and for molybdenum at 1,300 deg. C. Again, considering stress rupture strength for a life of 10 hr. at a temperature of 1,000 deg. C., tungsten withstands a stress of nearly 15 t.s.i. and molybdenum withstands $8\frac{1}{2}$ t.s.i.

Thus, in these two metals there would at first sight appear to be the basis of useful alloys for high-temperature applications, with molybdenum the weaker of the two but with the lower density (10·2 gm./cc. compared with 19·3 gm./cc. for W). Unfortunately, both these metals are rapidly destroyed by oxidation at temperatures above 600 deg. C. and neither can be considered for applications at high temperatures in oxidising atmospheres.

Attempts have been made to reduce the oxidation of molybdenum to tolerable rates by alloying or by coating the surface. Rengstorff[7] has made a survey of the effect of twenty-four alloying additions on the rate of oxidation.

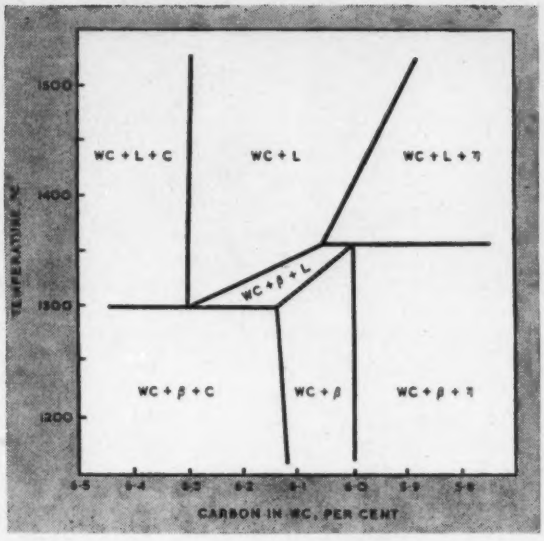


Fig. 2. Vertical section at 16 per cent cobalt of W-Co-C equilibrium diagram (according to Gurland).

Some ternary alloys were also investigated. In spite of the wide field covered, he concluded that it is unlikely that any molybdenum alloy would be found in which high resistance to oxidation at 980-1,100 deg C. is combined with the good physical properties of unalloyed molybdenum. Even with 15 per cent nickel or 25 per cent chromium, the rate of oxidation was still many times greater than could be tolerated in high-temperature applications, but the desirable physical properties were entirely destroyed.

At present, the best that has been achieved with tungsten and molybdenum (and with other so-called refractory metals) by alloying is to reduce their rate of oxidation by a factor of ten or so. This is not nearly good enough, and one cannot as yet see even a glimpse of the distant goal of oxidation-resistant alloys of these metals.

Since alloying has so far failed to solve the problem, attempts have been made to find a satisfactory coating. Progress on these lines has been reported by Hertzig and Blanchard[8] and by Harwood.[9]

The properties essential in a coating are numerous and complex. It must have adequate resistance to oxidation; good resistance to thermal shock; some degree of resistance to impact and abrasion; and it must withstand 1 or 2 per cent of creep.

Of plated coatings, electrodeposited layers of chromium and nickel offer the best protection at temperatures up to 1,100 deg. C., and can be applied to quite complicated shapes. Harwood reports that, with an undercoating of chromium and an outer coating of nickel, thousands of hours of protection at 930 deg. C. can be obtained, but it is insufficient at 1,200 deg. C.

Cladding with oxidation-resistant alloys has been tried. High nickel alloys are very promising, but tend to spall on cooling to room temperature. Of sprayed coatings, Al-Cr-Si and Ni-Cr-B are promising. The former alloy has better resistance to thermal shock, but the latter is better against impact (e.g., against high-velocity particles).

One of the best coatings is molybdenum disilicide produced by vapour deposition, hot-dipping in molten silicon, pack coating in silicon powder, etc. The life in still air can be in excess of 2,000 hr. at 1,100 deg. C. or 200-800 hr. at 1,370 deg. C. Unfortunately, molybdenum disilicide has poor resistance to impact, poor ductility, poor fatigue

Fig. 3 (left). Build-up on cutting tool after machining Meehanite at low speeds. Fig. 4 (centre). Flattened type of build-up after machining at higher speeds. Fig. 5 (right). Disappearance of build-up and appearance of cratering at still higher speeds.

resistance and has to be applied at a temperature above that at which molybdenum recrystallises. Ceramic coatings have similar disadvantages and it is doubtful whether they can be used for turbine blades.

Alloys of Tungsten

Before 1938, the need for metals of high density for shielding against X-rays and gamma rays was recognised. Tungsten has many advantages over lead, but it cannot be produced in the large pieces which would be required. Sintered alloys of tungsten, nickel and copper (the so-called "heavy alloys") were therefore developed, and have found increasing applications where their high density (16-18 gm./cc.) is useful. These include shielding, balance weights, rotating parts where a great mass is required, weights for automatic watches, and so on.

Several years ago Green, Jones and Pitkin[10] showed that the mechanical properties depend on the rate of cooling from the sintering temperature. Alloys which are rapidly cooled have a tensile strength over 40 t.s.i. and an elongation of 1 or 2 per cent, whereas slowly-cooled alloys sometimes have a tensile strength as low as 25 t.s.i. with less than 1 per cent elongation.

In the same paper these authors described most interesting properties obtained with tungsten-nickel-iron alloys. An alloy of 90 per cent tungsten, 7 per cent nickel and 3 per cent iron sintered at temperatures between 1,420 and 1,460 deg. C. (a little higher than is used for tungsten-nickel-copper alloys) has a density between 17 and 17·09 gm./cc. When slowly cooled, tensile strengths between 52 and 70·4 t.s.i. are obtained with elongations from 4-22 per cent.

Hard Metals

With hard metals (sintered carbides), the carbon content is very important. Gurland[11] has studied the effect of carbon content on the structure and properties of sintered alloys of tungsten carbide and cobalt, especially on the formation of η phase (the brittle double carbide of tungsten and cobalt). By sintering alloys at 1,400 deg. C. and quenching from various temperatures, a vertical section through the ternary diagram at 16 per cent cobalt was obtained. This is shown in Fig. 2. If the carbon content of the tungsten carbide is 6 per cent or less, η will persist at room temperature whatever the rate of cooling. If the carbon content is between 6 and 6·06 per cent, η phase will be found at room temperature only by rapid cooling from a narrow temperature range (just above 1,300 deg. C.). With still higher carbon contents, η phase will never occur.

The same author also studied grain growth in these alloys and advanced the theory that discontinuous grain growth is associated with the elimination of η phase by carburising during sintering. He considered that other factors may also play a part; for example, temperature variations, contiguous grains of low interfacial energy, etc. However, this theory does not have general agreement, and the subject has therefore, unfortunately, still not been clarified. Naturally, everyone who has had much experience with hard metals has a personal preference for one or other of the theories. Some mechanism involving the coalescence of grains, especially the absorption of small by large, may yet be found to be the basis of a satisfactory theory.

In spite of the well-known effect of cobalt content and grain size on the properties of sintered hard metals, there have been surprisingly few systematic investigations of these factors. Gurland and Bardzil[12] have made a valuable study of the relationship between strength, composition and grain-size of sintered WC-Co alloys. Whereas it has often been assumed that transverse strength increases with cobalt content (at least up to about 20 per cent) and with grain-size, these authors found that this was not so.

Their results are given in Fig. 3, which shows that at low cobalt contents (6-8 per cent) increase of grain-size gives increased strength. But at high cobalt contents (20 per cent and over) a finer grain-size gives the highest strength. Impact strength is greatly increased by increase of cobalt content, but does not seem to be affected by grain-size. Arguing that the strength of a sintered hard metal depends on the thickness of the layers of cobalt (or the "mean free path" through the binder phase), Gurland and Bardzil found that, in fact, the maximum transverse strength occurs over a fairly narrow range of mean free path (0·3-0·6 microns), whatever the grain-size.

Tungsten carbide (WC) has been used as the basis of sintered hard metals since their discovery, even though attempts have been made to find a better and preferably cheaper substitute. It is well known that oxides of tungsten are easily reduced by hydrogen (in contrast to many other carbide-forming metals), and that the carbide is well wetted by cobalt, nickel or iron. Suitable binder metals are therefore available and oxide films are no problem in sintering.

Recently, Gurland[13] has offered another explanation of the superiority of tungsten carbide to other carbides. He found that the transverse strength of sintered alloys consisting of one of the carbides WC, TaC, TiC, NbC, VC, ZrC, with cobalt contents of 10 and 37 volume-per cent, decreased in the order given above, and that there was an approximate correlation between the transverse strength and the Young's modulus of elasticity of the carbide, which also decreases in the same order.

At a recent meeting Trent[14] briefly discussed the process of ball-milling hard metal powders. Although this is a vitally essential part of the process, very little is known about what exactly happens during it. With tungsten carbide and cobalt much more than mixing is required to develop satisfactory properties after sintering. With a mixture con-

taining 6 per cent of cobalt, ball milling for only 4 hr. gives a sintered piece of very low density, and with increasing times up to 60 hr. the density increases. Ball milling therefore ensures freedom from porosity and good distribution of the cobalt. Nevertheless, there seems to be more in the process than this. It may be noted that with alloys of tungsten, nickel and copper, mixing of the constituents for a few hours is sufficient, but with hard metal powders ball-milling for several days is necessary. This may possibly be due to the considerable difference in the state of aggregation of the constituents. Tungsten powder is usually only slightly aggregated, whereas tungsten carbide, being made at temperatures above 1,400 deg. C., contains considerable aggregates which possibly have to be broken down.

Various other theories have been advanced. Hoyt in 1930 suggested that during milling the grains of carbide were coated with cobalt and this has apparently been fairly well accepted without there being very much evidence to support it. As regards evidence against it, if a mixture of tungsten carbide and cobalt (10·43 per cent Co) which has been ball-milled for 60 hr. or longer is dispersed in water and allowed to stand for an hour or so until some has settled out, the fraction which has not settled is found to contain only 2·80 per cent cobalt. Very much of the cobalt, therefore, settles independently of the tungsten carbide. It can therefore be seen from this brief discussion that the effect of ball-milling is very imperfectly understood.

During the pressing of hard metal powders a very non-uniform distribution of pressure often results. This causes differences of contraction during sintering with warping and dimensional errors. Recently, Penrice[15] has described an interesting and novel way of hydrostatic pressing. He uses a reversible gel as a mould; that is, a mould which can be deformed under pressure but which regains its original shape and dimensions on release of the pressure. Such a gel compresses like a liquid and transmits a uniform pressure on all faces of the powder compact. Plasticised polyvinylchloride is suitable.

In practice, a steel pattern of the compact is made having all its dimensions increased by a ratio which depends on the contraction which will take place in passing from the loose powder to pressed compact and thence to the sintered part. This pattern is put in a steel mould and molten plastic is poured in to fill the space between the pattern and the mould. The pattern is then removed, the cavity is filled with powder, and pressure is applied to the plastic mould through a steel plunger from a suitable press. Pressure is thereby exerted on the powder uniformly in all directions. The plastics mould can have a cavity of any desired shape and spheres can be pressed. It can be re-used many times.

Naturally, the machining of metals with sintered carbides has been studied ever since these alloys were first made. Harding and Trent[16] have investigated the machining of two grades of Meehanite with Wimet Grade N tools. At low speeds and feeds, build-up of metal takes place on the top face of the tool which protects it from wear either on the top face or the side clearance. Fig. 3 shows the distorted fragments of iron adhering to a tool. At higher cutting speeds or higher feeds, the build-up gradually decreases and becomes flattened and wedge-shaped towards the edge (see Fig. 4), but it still protects the tool. At still higher speeds or feeds, the build-up disappears (see Fig. 5) and a rapid cratering type of wear takes place on the top of the tool. The rate of wear on the front clearance or flank of the tool is very slow with the first type of build-up; it is greater with the other type, and increases very rapidly just before the build-up disappears. At high speeds and feeds, the temperature and pressure on the cutting edge become so great that the edge deforms and bulges towards the work-piece. In consequence, rapid flank wear takes place.

All these observations have been summarised by these authors graphically, and Fig. 1 shows a typical one for

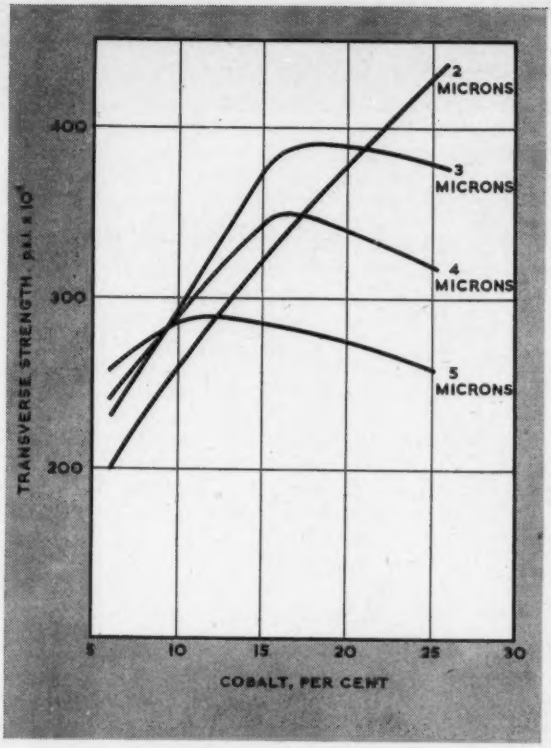


Fig. 6. Variation of transverse strength of WC-Co alloys with cobalt content and grain size (according to Gurland and Bardzil).

Meehanite Type GA machined with Wimet Grade N. It shows the range of speeds and feeds over which various stages of build-up occur and where build-up disappears. Also on this graph are the lines denoting the point at which flank wear and deformation become serious.

The practical importance of this and similar charts is that they show, for one particular metal with one particular grade of hard metal, the range of speeds and feeds over which build-up occurs with consequent protection of the cutting edge (when cutting cast iron), and the range over which wear or deformation become serious. Therefore, although the charts are derived from short time tests, they give a sure guide to the ultimate mode of failure of the tools. In fact, the authors showed that a series of workshop tests agreed very well with the short time tests.

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This is an abridged version of an article which first appeared in the *Alloy Metals Review*, published by High Speed Steel Alloys Ltd.

designer's notebook

A Novel Self-locking Wormgear Transmission of High Efficiency

A TYPE of worm transmission having self-locking features is claimed by the inventors, B. Popper and D. W. Pessen, to have a theoretical efficiency that can almost reach 100 per cent. The Twinform drive, as the gear is called, formed the subject of a paper recently presented to the A.S.M.E.* The inventors believe that the Twinform drive should make a valuable new machine tool element at the disposal of the machine designer.

A conventional worm transmission consists of a worm driving a worm wheel, with their axes normal to one another. The Twinform drive, however, consists of two worms in mesh, their axes almost parallel to each other, as shown in Fig. 1. The threads of the two worms are right- and left-handed respectively. Unlike the conventional worm drive, the transmission ratio of the Twinform can be made either smaller or larger than 1, according to requirements, and a ratio of 1 : 1 is also claimed to be possible. The inventors point out, however, that the object of the Twinform is not to provide very large speed reductions, as these can more easily be obtained with conventional worm drives. Its purpose is to produce self-locking without any sacrifice in efficiency. The unique properties of the drive are dependent upon a completely different range of pitch angles and axes angles than are used in conventional worm drives.

The self-locking feature of the Twinform drive can be of two kinds: ordinary self-locking and second-order self-locking. Ordinary self-locking means that if gear 1 is designed to be the driver and gear 2 the follower, then gear 1

Fig. 2

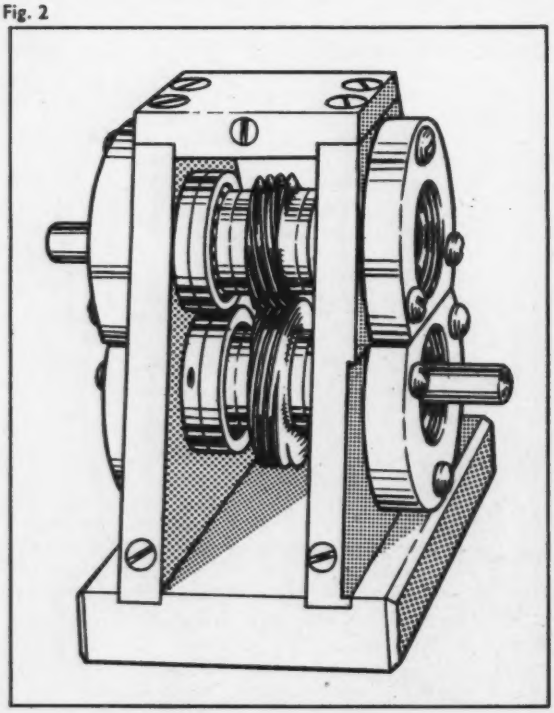
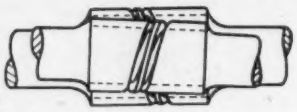
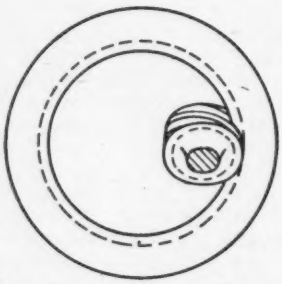


Fig. 1



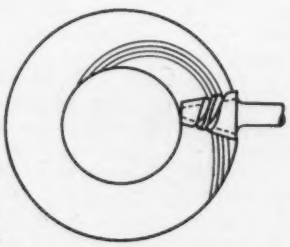
Twinworm drive

Fig. 3



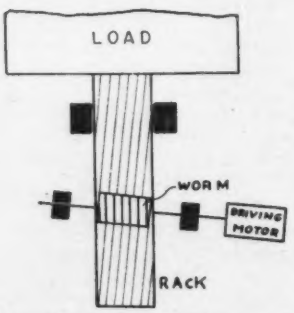
Internal Twinworm drive

Fig. 4



Bevel Twinworm drive

Fig. 5



Twinworm principles applied to worm-rack drive

can drive gear 2 in either direction, but gear 2 cannot drive gear 1 in any direction. The disadvantage of the conventional self-locking worm drive or self-locking power screw is that efficiency can never be more than the theoretical maximum of 50 per cent, which, in practice, is usually closer to 40 or 45 per cent. The much higher efficiency of the Twinform is claimed to be particularly advantageous in lifting applications, as it would enable much smaller drive motors to be used. It would therefore appear to have advantages in hoists, lifts, elevators, actuator mechanisms, heavy drill presses and for mechanisms for adjusting the seats of cars and for raising and lowering windows. Another surprising advantage claimed is that it can be designed so that the same input torque is required both for raising and for lowering the load, even if no counterweight is used.

A further application concerns the use of the drive in differential gears in computing mechanisms. If a resisting torque is applied to the output shaft of a differential, it is possible for the input shaft to one side of the differential to move slightly at the expense of the output shaft. This movement could be prevented by connecting each input shaft to the differential through a Twin-form drive.

The second-order type of self-locking, for which a separate design formula is used in order to derive the appropriate pitch and axis angles, includes all the properties of ordinary self-locking. In addition, however, as soon as gear 2 tries to go faster than it is being driven by gear 1 (as would occur if gear 2 is "helped") the whole transmission is immediately locked. For example, if the output shaft of a Twinform drive were to carry a small flywheel and the input shaft were suddenly to stop, the inertia of the flywheel attached to the output shaft would tend to make it go faster than it was being driven by input shaft 1. The whole transmission would immediately stop turning. If, however, the flywheel were to be connected to the shaft in a flexible manner by means of a torsion spring, then the drive would be locked even before the acceleration of the input shaft became negative. A demonstration model of a Twinform drive having second-order self-locking is shown in Fig. 2.

The advantages of second-order locking characteristics make the Twinform drive principle an interesting proposition for the following kinds of application. By connecting the drive to a position servo-mechanism, overshoot of the servo output can be completely prevented, thus providing almost perfect damping characteristics. In machine tool applications or even in dental drills, where it is frequently desirable to bring the drill or cutter to a stop when sudden break through and consequent acceleration of the cutter spindle can occur, is another interesting field of application. The same kind of problem also occurs in winding machinery.

Figs. 3, 4 and 5 show possible variants of the Twinform drive. It is claimed that the manufacture of the components of the drive will not be difficult, as the worms can be cut on a lathe, or even on an automatic screw machine, in the same way as ordinary screw threads. The load-bearing capacity of the Twinform drive is claimed to be higher than that of ordinary worm drives, since their high efficiency results in very little heating of the threads. Wear, also, will be low for the same reason.

* *A.S.M.E. Paper No. 59-A-75.*

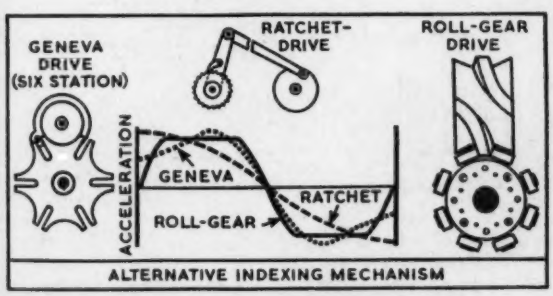
Mechanisms for High-speed Indexing

A GREAT variety of mechanisms are employed in deriving intermittent rotary motion from a uniform input. Two of the best known are the ratchet type and the Geneva-wheel type, both driven pulsively by simple cranks. The efficiency of such basic devices has become specially significant in the development of automatic production machines because of the continuous trend toward higher speed operations.

Superior indexing efficiency and servicing economy are now claimed for an alternative mechanism developed in the U.S.A. as a precision commercial unit and available* in a variety of models. This is the Ferguson Roll-gear drive comprising essentially a tool-steel ribbed barrel-cam driving a simple wheel with radial rollers. These are mounted on preloaded rolling bearings, two rollers contacting the tapered rib at all times.

The diagrams below compare typical performance of the three basic types of mechanism. The Ferguson drive is characterised by a modified trapezoidal acceleration curve with zero initial force as compared with the appreciable starting and stopping forces applied instantaneously to Geneva and ratchet wheels. The resultant smooth action of the Roll-gear is said to permit as many as 1,000 precision indexes per minute with a minimum of 8,000 hours' operation while maintaining extreme accuracy with zero backlash. Rolling bearing replacement renews the drive, as wear of the cam (hardened to Rockwell C-50) is comparatively negligible over very long periods.

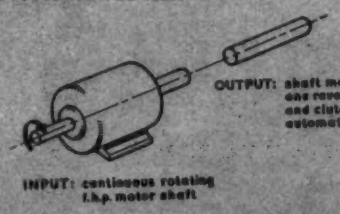
* *Ferguson Machine Corp. of Indiana.*



ALTERNATIVE INDEXING MECHANISM

Best solutions to "Problems in Design" are published and paid for. Send your solution for this month, with a drawing or diagram (in Indian Ink and not more than 12 × 12 in., please !), to The Editor, E.M.&D., marked "Problems in Design No. 5 (March)". Closing date April 15.

THIS MONTH'S PROBLEM


OUTPUT: shaft makes exactly one revolution only and clutches out automatically
INPUT: continuous rotating f.h.p. motor shaft

In a knot-tying machine it is necessary to provide a means whereby (by the pressing of a button to operate an electro-mechanical clutch, or by the operation of a lever) a shaft on the same axis as that of the power source, a f.h.p. motor, is caused to rotate exactly one revolution and then stop. The output shaft speed to be approx. 1/10 of the input motor shaft. The input motor shaft runs continuously. Direction of rotation of the output shaft can be the same as the input shaft or in the opposite direction. If it is decided to use a standard motor and clutch unit, details of the clutch need not be shown. Mechanical braking of the output shaft is not permissible.

We welcome design problems from our readers. These should be in the fields of simple mechanical, hydraulic or compressed air engineering and not specific to a particular application. All problems published will be paid for.

WHERE TO FIND TECHNICAL INFORMATION

This quick reference guide to the main sources of information useful to the designer has been specially compiled by E.M.D. staff

THE rapid developments which have taken place in science and technology not only make it difficult for engineers to keep up to date with their technical knowledge, but have also made it all the more essential to do so, in order that their designs and products should keep abreast of those of their competitors, both in this country and abroad. As knowledge and techniques continue to grow in extent and complexity, the need for "short-cuts" arises because time does not allow every engineer to learn by experience before making decisions on new or improved designs.

The accumulated knowledge of all the organisations carrying out research and development on subjects of interest to the engineer is clearly enormous, and one of the biggest problems is indexing and disseminating this information to those who require it. It may be argued that distribution of technical literature should enable all this knowledge to be made available immediately to those who require it, but in fact much useful data never arrives in the hands of those who particularly want it or it may not arrive at the right time. A recent publication[1] has shown that the majority of technologists in any case do not consult literature when faced with a technical problem, but they try to find someone who has a ready answer to their questions. In large organisations there is often an expert within easy reach, but smaller companies may need outside advice. Where advice is not readily to hand, many engineers take the steps of initiating their own simple experiments, which are often badly conceived in the first place and badly carried out by inexperienced staff with inadequate facilities.

The wastage of manpower and time in such experiments in industry is very great, but a more serious fault is that when not properly executed they give results which may be wrong or misleading. The alternative to such action, if we discount a direct approach through literature, which in any case demands a specialised technique if it is to be done properly, is to have available a list of persons or organisations who can be reached quickly and easily and who are prepared to give technical advice.

The preparation of such a list is no easy task and many engineers do not have the time to compile their own. We have therefore made an attempt to list those organisations which operate a technical inquiry service or which employ specialists who may be consulted. This list does not include the many manufacturing companies who offer a technical service as part of their sales policy, but we have tried to include all the research associations and technical institutions who may be able to help engineers and designers.

Many of these associations represent a group of manufacturers and will be able to redirect technical inquiries to the appropriate quarter.

It is not claimed that the lists provided here are comprehensive or that the classified list is absolutely complete, but we feel that this should not lessen its value. In seeking technical information it is often only necessary to initiate an inquiry, perhaps to the wrong authority, as it is usual for information and liaison officers as well as librarians to have an extensive knowledge outside their own specific field, so that in cases where they cannot help directly they can usually redirect the inquirer to the correct source of information.

It is felt that it would be inappropriate to extend the present article to a survey of books, periodicals, abstracts and the many other forms of literature which can be of help to the practical engineer. In any case, many of the authorities listed have extensive libraries with a qualified librarian in charge, and for quick results it is better to consult them, rather than plunge into the bewildering systems of libraries oneself. In making this statement, it must be understood that we have drawn a distinction between the research worker, who may wish to carry out a thorough search himself, and the practical engineer, with whose interests we are primarily concerned.

FOR FURTHER READING:

1. *What They Read and Why.* By Nigel Calder, D.S.I.R., London, S.W.1. (H.M.S.O., 2s.)
2. *How to Set up Your Firm's Technical Information Service.* European Productivity Agency, O.E.E.C. (H.M.S.O.)
3. *International Guide to European Sources of Technical Information.* E.P.A., O.E.E.C. (H.M.S.O., 16s.)
4. "Information Service on Electronics", *Brit. Comm. and Electronics,* December 1955, **2**, No. 12, pp. 66-70.
5. *Sources of Engineering Information.* (Bibliography.) By Blanche H. Dalton. University of California Press, 1949.

SAVE TIME BY USING THE SELECTION GUIDE ON PAGE 159

Key Initials		Name and Address	Objects and Service
A.D.A.		Aluminium Development Assoc., 33 Grosvenor St., London, W.1. (Mayfair 7501).	Aluminium and its alloys, particularly effective and correct application. Staff of engineers to cover all major industries.
A.M.S.	M	Assoc. of Metal Sprayers, Barclays Bank Chambers, Dudley, Worcs. (Dudley 4045).	To obtain maximum production with maintenance of quality; to promote interchange of technical knowledge; to conduct and encourage research.
A.S.E.E.	M	Assoc. of Supervising Electrical Engineers, 23 Bloomsbury Sq., London, W.C.1 (Langham 5927).	Caters for technical employees in supervisory or administrative positions in electrical and allied industries.
A.S.L.I.B.	M	ASLIB, 3 Belgrave Sq., London, W.1 (Belgravia 5050).	Directs firms to sources of technical information and provides assistance in setting up and running library, information and translation services. Promotes exchange and efficient use of technical information.
B.B.I.R.A.		British Baking Industries Research Assoc., Chorleywood, Herts. (Chorleywood 900).	Research into many aspects of food production, including design of machinery and materials used in their construction.
B.C.I.R.A.		British Cast Iron Research Assoc., Bordesley Hall, Alvechurch, Birmingham (Redditch 716).	Iron foundry practice and control; uses of cast iron; new materials and techniques; working conditions.
B.Cot.I.R.A.	M	British Cotton Industry Research Assoc., Shirley Institute, Didsbury, Manchester, 20 (Didsbury 2401).	Study of uses of cotton, natural silk and man-made fibres, from evaluation of raw materials, preparation, spinning and weaving, to dyeing and finishing, and from properties of cellulose to design of machinery.
B.C.P.M.A.		British Chemical Plant Manufacturers Assoc., 14 Suffolk St., London, S.W.1 (Whitehall 0766).	Mainly concerned with commercial activities of British chemical plant industry, but technical information on sources of supply of chemical engineering equipment.
B.C.R.A.	M	British Ceramic Research Assoc., Queens Rd., Penkhull, Stoke-on-Trent, (Stoke 44045).	Character and classification of raw materials for pottery, refractories and heavy clay products; manufacturing processes; design and performance of machinery and kilns; high-temperature properties of refractories.
B.C.U.R.A.	M	British Coal Utilisation Research Assoc., Randalls Rd., Leatherhead, Surrey (Leatherhead 4411).	Information on coal utilisation and related fields of science and technology.
B.E.A.		British Engineers Association, 32 Victoria St., London, S.W.1 (Abbey 2141)	Information service for engineers seeking all types of mechanical engineering products equipment. Extensive records of manufacture and trade names in U.K. and abroad.
B.E.D.A.		British Electrical Development Assoc., 2 Savoy Hill, London W.C.2 (Temple Bar 9434).	All branches in utilisation and allied fields: instrumentation, control, lighting, heating and ventilating, etc.
B.G.I.R.A.		British Glass Industry Research Assoc., Northumberland Rd., Sheffield, 10 (Sheffield 64564).	Materials, processes and products in glass manufacture; new glasses.
B.H.R.A.		British Hydromechanics Research Assoc., South Rd., Temple Fields, Harlow, Essex. (Harlow 24366).	Fundamental fluid mechanics; pumps and turbines; control and motion of fluids in pipes and valves; hydraulic transmission of power; seals and glands.
B.I.C.E.M.A.	M	British Internal Combustion Engine Manufacturers Assoc., 6 Grafton St., London, W.1. (Hyde Park 5107).	Matters relating to manufacture of I.C. engines.
B.I.C.E.R.A.	M	British Internal Combustion Engine Research Assoc., 111–112 Buckingham Ave., Slough, Bucks (Slough 20295).	I.C. engineering, pressure charging, noise reduction, vibration, combustion, fuels, lubricants, stress analysis, fuel injection and instrumentation.
B.I.C.T.A.		British Investment Casters Technical Assoc., 5 East Bank Rd., Sheffield, 2 (Sheffield 28647).	Investment casting and its application.
B.I.M.C.A.M.		The BIMCAM Assoc., 9 Argyll St., London, W.1 (Regent 0568).	A central body to foster the interests and efficiency of the British industrial instruments industry.
B.I.S.R.A.		British Iron and Steel Research Assoc., 11 Park Lane, London, W.1 (Grosvenor 4751).	Corrosion, steelmaking, computer applications, metallurgy, physics, chemistry, metal working and general engineering problems, etc.
B.N-F.M.R.A.	M	British Non-Ferrous Metals Research Assoc., Euston St., London, N.W.1 (Euston 6411).	Properties, fabrication and uses of non-ferrous metals; melting, casting and working; galvanising, electroplating and other surface finishing.
B.P.B.I.R.A.	M	British Paper and Board Industry Research Assoc., St. Winifred's Laboratories, Welcomes Rd., Kenley, Surrey (Uplands 6401).	Problems in paper mills, performance testing of paper, paper coatings.

Key Initials		Name and Address	Objects and Service
B.P.F.		British Plastics Federation, 47–8 Piccadilly, London, W.1 (Regent 4681).	Maintains a technical library and information bureau and publishes monthly abstract journal.
B.R.E.M.A.	M	British Radio Equipment Manufacturers Assoc., 59 Russell Sq., London, W.C.1 (Museum 6901).	Domestic radio and television and sound reproduction, component standardisation.
B.R.R.A.		British Rayon Research Assoc., Heald Green Laboratories, Wythenshawe, Manchester, 22 (Gatley 4285).	Techniques for handling and treatment of synthetic fibres; properties of rayon fibres; new and improved machines for opening, spinning, weaving, dyeing and finishing.
B.R.S.		Building Research Station, Garston, Watford, Herts. (Garston 4040).	Study of the efficiency of building operations, quality of completed buildings and building materials. Design of structures, heating, lighting and ventilating of buildings.
B.S.C.R.A.	M	British Steel Castings Research Assoc., East Bank Rd., Sheffield, 2 (Sheffield 28647).	Raw materials. Machines and processes. Products. Sampling and testing. Health in steel foundries.
B.S.F.A.		British Steel Founders Assoc., Broomgrove Lodge, 13 Broomgrove Rd., Sheffield, 10 (Sheffield 63046).	Technical and commercial service on steel casting.
B.S.I.		British Standards Institution, 2 Park St., London, W.1 (Mayfair 9000).	A national body responsible for industrial standards and codes of practice in the U.K. Library open to all and is central reference to national and international standards.
B.S.R.A.	M	British Shipbuilding Research Assoc., 5 Chesterfield Gdns., Curzon St., London, W.1 (Grosvenor 8891).	Correlation of model and full-scale tests; performance of vessels in service; ship structures and machinery; materials and design; hydrodynamics.
B.W.R.A.	M	British Welding Research Assoc., Abington Hall, Cambridge (Linton 375). 29 Park Cres., London, W.1 (Langham 7485).	Welding processes and techniques; welding for fabrication and repair; performance of welded structures; non-destructive testing.
C.A.C.A.		Cement and Concrete Assoc., 52 Grosvenor Gdns., London, S.W.1 (Belgravia 6661).	Development in all uses of cement and concrete, durability, design of structures and building techniques.
C.D.A.		Copper Development Assoc., 55 South Audley St., London, W.1 (Grosvenor 8811).	Information on copper and its alloys, mainly concerned with the application of the results of research. Issues large number of technical publications free of charge.
C.E.A.	M	Combustion Engineering Assoc., 70 Jermyn St., London, S.W.1 (Whitehall 5723).	Combustion engineering, selection of fuel for industrial purposes, fuel-burning appliances and ancillary equipment.
C.O.I.D.		Council of Industrial Design, 28 Haymarket, London, S.W.1 (Trafalgar 8000).	A government body appointed to improve the standard of British design throughout manufacturing and distributive trades, including engineering products.
C.S.F.R.O.	M	Coil Spring Federation Research Organisation, Hoyle St., Sheffield, 3 (Sheffield 28941).	Design and testing of springs; materials; processes and heat treatment; protective coatings.
D.S.I.R.		Department of Scientific and Industrial Research, Charles House, 5–11 Regent St., London, S.W.1 (Whitehall 9788).	Technical inquiries either directly or through associated research stations. British agents for the European Productivity Agency question-and-answer service run for the benefit of O.E.E.C. member countries.
E.I.A.	M	Engineering Industries Assoc., 9 Seymour St., Portman Square, London, W.1 (Welbeck 2241).	Advise to members on any matter which may arise in the course of their business and to protect their interests.
E.R.A.	M	Electrical Research Assoc., Cleeve Rd., Leatherhead, Surrey (Leatherhead 4151).	Generation, transmission and distribution of electricity; uses; study of insulating, magnetic and structural materials for electrical equipment; design of electrical and electronic equipment and consumer appliances.
F.P.R.L.		Forest Products Research Laboratory, Princes Risborough, Bucks. (Princes Risborough 101).	Studies of attack of timber by insects and fungi, wood bending and preservation, and timber mechanics.
F.R.I.	M	Fulmer Research Institute, Stoke Poges, Bucks. (Fulmer 180).	Conducts research on a very wide range of subjects on fee basis. Will carry out any form of analysis, testing or research.
F.R.O.		Fire Research Organisation, Fire Research Station, Boreham Wood, Elstree, Herts. (Elstree 1341).	Studies initiation and growth of fire in materials, hazards in various industries, smoke and fire-fighting equipment, etc.
G.M.F.		Glass Manufacturers Federation, 19 Portland Pl., London, W.1 (Langham 6952).	Mainly commercial and educational aspects of glass, but can advise on sources of supply and trade names.
H.V.R.A.	M	Heating and Ventilating Research Assoc., Old Bracknell Lane, Bracknell, Berks. (Bracknell 2071).	Carries out research on all aspects of heating and ventilating and allied subjects.

Key Initials		Name and Address	Objects and Service
I.E.D.	M	Institution of Engineering Designers, 38 Portland Pl., London, W.1 (Langham 8847).	Professional body of engineering designers and draftsmen concerned primarily with technical design.
I.E.E.	M	Institution of Electrical Engineers, Savoy Pl., London, W.C.2 (Covent Garden 1871).	To promote advancement of electrical science and engineering, to facilitate the exchange of information and to assist financially the promotion of inventions and research.
I.E.I.	M	Institution of Engineering Inspection, 28 Victoria St., London, S.W.1 (Abbey 3794).	All matters relating to engineering inspection and quality control.
I.G.E.	M	Institution of Gas Engineers, 17 Grosvenor Cres., London, S.W.1 (Sloane 8266).	To promote engineering science as applied to the gas industry and to facilitate the exchange of information among its members.
I.H.V.E.	M	Institution of Heating and Ventilating Engineers, 49 Cadogan Sq., London, S.W.1 (Sloane 3158).	To promote the science and practice of heating, ventilating, air conditioning, drying, domestic hot water supplies and all allied branches of engineering.
I.Mar.E.	M	Institute of Marine Engineers, The Memorial Building, 76 Mark Lane, London, E.C.3 (Royal 8493).	To promote scientific and practical development of marine engineering in all aspects.
I.M.M.	M	Institution of Mining and Metallurgy, 44 Portland Pl., London, W.1 (Langham 3802).	Information on the mining and extraction metallurgy of ferrous and non-ferrous metals.
I.P.		Institute of Petroleum, 61 New Cavendish St., London, W.1 (Langham 3583).	Reference library of information on the petroleum industry (members having additional privilege of being able to borrow books). Information supplied provided it can be obtained from published literature.
I.Pat.I.	M	Institute of Patentees and Inventors, 207–8 Abbey House, 2–8 Victoria St., London, S.W.1 (Abbey 1616)	Advice and assistance to members on all aspects of patenting inventions.
I.Prod.E.	M	Institution of Production Engineers, 10 Chesterfield St., London, W.1 (Grosvenor 5254).	To promote the science and practice of production engineering.
I.R.	M	Institute of Refrigeration, New Bridge Street House, New Bridge St., London, E.C.4 (Central 4694).	To promote general advancement of refrigeration in all its applications, both to perfect methods and to extend services to the community.
I.S.I.	M	Iron and Steel Institute, 4 Grosvenor Gdns., London, S.W.1 (Sloane 0061).	Collects and disseminates knowledge relating to the manufacture, use and properties of iron and steel.
I.S.M.E.	M	Institute of Sheet Metal Engineers, John Adam House, London, W.C.2 (Trafalgar 6171).	Technical advice on practical problems available to all users of sheet and strip metal and to those interested in its manipulation, fabrication and allied processes.
I.W.	M	Institute of Welding, 54 Princes Gate, London, S.W.7 (Knightsbridge 8556).	Information on metal spraying, inspection and testing, applications of welding and brazing and metal cutting.
L.D.A.		Lead Development Assoc., 18 Adam St., London, W.C.2 (Whitehall 4175).	Promotion of co-operation between manufacturers and users of lead and its alloys.
M.I.R.A.	M	Motor Industry Research Assoc., Lindley, Nr. Nuneaton, Warwickshire (Nuneaton 3664).	Performance of vehicles; power units; vehicle structure transmission and brakes; fuels and lubricants; noise suppression and testing under wide range of conditions.
N.E.L.		National Engineering Laboratory, East Kilbride, Glasgow (East Kilbride 20222).	Experimental, advisory and design consultancy services for wide range of engineering subjects including properties and strength of materials, plastic flow and metal forming processes, hydraulic machinery, lubrication and wear, mechanisms, metrology and noise control, heat transfer and applied thermodynamics.
N.I.C.E.I.C.		National Inspection Council for Electrical Installation Contracting, Alldine House, 10–13 Bedford St., London, W.C.2 (Covent Garden 1163).	Carries out inspection of electrical installations with a view to protecting the consumer against faulty or unsafe electrical installations or appliances.
N.P.L.		National Physical Laboratory, Teddington, Middlesex (Molesey 1380).	Fundamental and applied research in all aspects of physics. Facilities for accurate measurement of physical properties of materials.
N.R.D.B.		Natural Rubber Development Board, Market Buildings, Mark Lane, London, E.C.3 (Mansion House 9383).	Free technical informations service covering all aspects of natural rubber including engineering uses.
P.A.T.R.A.		Printing and Allied Trades Research Assoc., Patra House, Randalls Rd., Leatherhead (Leatherhead 4041).	Research into printing and packaging problems, adhesives, attack by insects and moulds, and effects of storage and climate.

Key Initials		Name and Address	Objects and Service
P.E.R.A.	M	Production Engineering Research Assoc., Melton Mowbray, Leics. (Melton Mowbray 4133).	Design and performance of machine tools; use of grinding and cutting tools; properties and application of cutting fluids; abrasives; sheet metal pressing; metal forming and behaviour of metals.
P.M.A.		Permanent Magnet Assoc., Central Research Laboratory, 84 Brown St., Sheffield, 1 (Sheffield 24318).	Carries out research into all aspects of permanent magnet materials and recognised as a leading authority on the subject.
P.M.E.T.R.D.A.	M	Parsons and Marine Engineering Turbine Research and Development Assoc., Pametrada Research Station, Wallsend, Northumberland (Wallsend 64061).	Marine use of steam and gas turbines; transmission and gearing; static tests.
P.O.L.		Patent Office Library, 25 Southampton Bldgs., Chancery Lane, London, W.C.2 (Holborn 8721).	Library of patents, books and periodicals, pamphlets and trade catalogues. Photocopying service.
P.O.R.S.		Post Office Research Station, Dollis Hill, London, N.W.2 (Gladstone 3376).	Applied research and development in connection with post office services, including line and radio transmission, telephone switching, electronics, physics, chemistry, metallurgy and electro-acoustics.
R.A.B.P.		Research Assoc. of British Paint, Colour and Varnish Manufacturers, Paint Research Station, Waldegrave Rd., Teddington, Middlesex (Molesey 4427).	Preparation of paint, varnishes and other compositions; assessment of raw materials; properties and performance of paints.
R.A.B.R.M.		Research Assoc. of British Rubber Manufacturers, Shawbury, Shrewsbury, Salop (Shawbury 383).	Raw materials and components; evaluation of synthetic rubbers; ageing development of test methods and instruments; dynamic properties of rubber; special purpose rubbers.
R.A.G.B.		Refractories Assoc. of Great Britain, c/o J. & J. Dyson Ltd., Stannington, Sheffield (Sheffield 44245).	Formed to provide a means of joint action in all matters pertaining to the refractories and allied industries.
R.A.S.	M	Royal Aeronautical Society, 4 Hamilton Pl., London, W.1 (Grosvenor 3515).	Covers aerodynamics, structures, aircraft performance and fatigue. Issues data sheets giving up-to-date design information for aircraft design and development.
R.R.S.		Radio Research Station, Ditton Park, Slough, Bucks. (Slough 24411).	Studies of the properties of materials used in the manufacture of radio equipment.
S.G.T.	M	Society of Glass Technology, Thornton, Hallam Gate Rd., Sheffield, 10 (Sheffield 63168).	Joint library with the Dept. of Glass Technology of the University of Sheffield.
S.I.M.A.	M	S.I.M.A. Instrument Enquiry Service, South Hill, Chislehurst, Kent (Imperial 6000).	Studies of instruments, their components and performance; suitability of materials; optical computation.
S.M.L.		Science Museum Library, South Kensington, London, S.W.7 (Kensington 6371).	Covers all pure and applied science. Operates a loan service, photocopying service and supplies bibliographies.
S.P.R.L.	M	Sondes Place Research Laboratories Ltd., Dorking, Surrey (Dorking 3265).	Carries out sponsored research and development in chemistry, chemical engineering and mechanical engineering.
T.D.A.		Timber Development Assoc. Ltd., 21 College Hill, London, E.C.4 (City 4771).	Technical information and advisory service on timber products. Applications of timber; design of timber structures; performance testing; laminates board and plywood; wood preservation.
T.R.I.		Tin Research Institute, Fraser Rd., Perivale, Middlesex (Perivale 4254).	Research on tin and its alloys, advice on all technical problems, such as coating with tin, bearings, corrosion, etc.
V.E.D.C.		Vitreous Enamel Development Council, 28 Welbeck St., London, W.1 (Hunter 2237).	Free advisory service on all aspects of enamel and its use.
W.P.C.		World Power Conference, 201–2 Grand Bldgs., Trafalgar Square, London, W.C.2 (Whitehall 3966).	Authoritative source of information pertaining to energy statistics. Also on all matters relating to the World Power Conference Plenary and Sectional Conferences.
Z.A.D.C.A.		Zinc Alloy Die Casters Assoc., 34 Berkeley Sq., London, W.1 (Grosvenor 6636).	Technical advice on all matters concerned with zinc alloy die castings.
Z.D.A.		Zinc Development Assoc., 34 Berkeley Sq., London, W.1 (Grosvenor 6636).	Free technical service to all users of zinc. Associated with the Hot Dip Galvanizers Association (mainly concerned with corrosion prevention on steel), the Zinc Alloy Die Casters Association (see Z.A.D.C.A.) and the Zinc Pigment Development Association, which deals with the use of zinc pigments.

"M" indicates that the organisations concerned normally confine their information service to members or expect payment for advice given. Simple questions which do not require extensive search or practical investigation are sometimes answered to other bona fide inquirers.

GO TO THE RIGHT ORGANISATION FIRST TIME

(For details of organisations mentioned here, see previous pages)

Acoustics	B.R.S.
	P.O.R.S.
Adhesives	M.I.R.A.
	P.A.T.R.A.
	P.E.R.A.
	S.P.R.L.
	T.D.A.
Aerodynamics	R.A.S.
	N.P.L.
Air Conditioning	H.V.R.A.
	B.E.D.A.
	I.H.V.E.
	B.I.M.C.A.M.
	B.C.U.R.A.
	B.S.R.A.
	M.I.R.A.
	I.E.E.
	T.D.A.
Aluminium and Alloys	A.D.A.
Appliances (Fuel Burning)	C.E.A.
Atomic Energy	L.D.A.
	F.R.I.
	B.N-F.M.R.A.
Automobile Engineering	M.I.R.A.
Building Materials	B.R.S.
Castings:	
die	Z.A.D.C.A.
investment	B.I.C.T.A.
iron	B.C.I.R.A.
steel	B.S.C.R.A.
	B.S.F.A.
Cement and Concrete	C.A.C.A.
	S.P.R.L.
Ceramics	B.C.R.A.
	E.R.A.
	S.P.R.L.
	L.D.A.
	A.M.S.
Chemical Engineering Equipment	B.C.P.M.A.
Copper and Alloys	C.D.A.
Corrosion	Z.D.A.
	F.R.I.
	M.I.R.A.
	B.S.R.A.
	B.I.S.R.A.
	T.R.I.
	P.E.R.A.
	S.P.R.L.
	A.M.S.
	I.S.I.
	T.D.A.
	L.D.A.
	B.C.U.R.A.
	I.H.V.E.
	B.N-F.M.R.A.
	P.M.E.T.R.D.A.
Design:	
appearance	C.O.I.D.
building	B.R.S.
concrete	C.A.C.A.
food machinery	B.B.I.R.A.
textile machinery	B.Cot.I.R.A.
timber products	T.D.A.
welding	B.W.R.A.
general	B.C.U.R.A.
	Z.D.A.
	P.E.R.A.
	I.Prod.E.
	I.S.I.
	M.I.R.A.
	I.E.D.
	L.D.A.
	S.P.R.L.
	N.P.L.
Electrical (Engineering, supply and installations)	E.R.A.
	B.E.D.A.
	I.E.E.
	B.C.U.R.A.
	I.S.I.
	N.P.L.
	A.S.E.E.
	N.I.C.E.I.C.
Electronics	L.D.A.
	T.D.A.
	S.I.M.A.
	N.P.L.
	B.E.D.A.
	M.I.R.A.
	P.E.R.A.
	B.I.M.C.A.M.
	I.E.E.
	I.S.I.
	B.R.E.M.A.
	A.S.E.E.
	P.O.R.S.
	R.R.S.
Enamels (Vitreous)	V.E.D.C.
	F.R.I.
Energy Statistics	W.P.C.
Engines (I.C.)	B.I.C.E.M.A
	B.I.C.E.R.A.
Fatigue	R.A.S.
	N.E.L.
	B.N-F.M.R.A.
	N.P.L.
	B.I.S.R.A.
Finishes and Coatings	T.D.A.
	P.E.R.A.
	Z.D.A.
	A.M.S.
	R.A.B.P.
Fire-proofing	F.R.O.
Fuels	I.P.
	C.E.A.
	M.I.R.A.
Fuel and Power	B.C.U.R.A.
Fuel and Power Resources	B.E.D.A.
	I.G.E.
General Technical	D.S.I.R.
	ASLIB
	P.O.L
General Engineering	B.I.S.R.A.
	E.I.A.
	N.E.L.
Glass	L.D.A.
	S.I.M.A.
	S.G.T.
	M.I.R.A.
	G.M.F.
	B.G.I.R.A.
Heating and Ventilating	H.V.R.A.
	B.S.R.A
	B.I.M.C.A.M.
	T.D.A.
	M.I.R.A.
	B.C.U.R.A.
	I.E.E.
	B.E.D.A.
	P.E.R.A.
	I.H.V.E.
	B.R.S.
Hydraulics	N.E.L.
	B.H.R.A.
Illuminating Engineering	N.P.L.
Inspection and Testing	I.W.
	I.E.I.
Instruments	M.I.R.A.
	E.R.A.
	B.C.U.R.A.
	I.E.E.
	P.E.R.A.
	B.I.S.R.A.
	B.I.M.C.A.M.
	I.S.I.
	S.I.M.A.
	P.M.E.T.R.D.A.
Insulation (Electrical)	B.E.D.A.
	T.D.A.
	S.P.R.L.
	E.R.A.
	N.P.L.
	P.E.R.A.
	I.E.E.
	S.I.M.A.
Insulation (Heat)	P.E.R.A.
	N.P.L.
	S.P.R.L.
	T.D.A.
	S.I.M.A.
	I.H.V.E.
Insulation (Sound)	L.D.A.
	N.P.L.
Inventions	L.D.A.
	S.P.R.L.
	T.D.A.
	I.S.I.
	A.S.E.E.
	I.Pat.I.
Lighting	B.R.S.
	I.E.E.
	B.E.D.A.
	P.E.R.A.
	N.P.L.
	M.I.R.A.
	A.S.E.E.
Lubricants	(See Oils and Lubricants)
Lubrication	N.E.L.
	I.P.
	P.M.E.T.R.D.A.
Magnetic Materials	I.E.E.
	E.R.A.
	B.I.S.R.A.
	P.E.R.A.
	I.S.I.
	P.M.A.
	B.R.E.M.A
Marine Engineering	B.S.R.A.
	I.Mar.E
Marine Turbines	P.M.E.T.R.D.A.
Materials (Properties of)	R.R.S.
	B.R.S.
	C.D.A.
	A.D.A.
	B.I.S.R.A.
	N.E.L.
	N.P.L.
	Z.D.A.
	T.R.I.
	T.D.A.
	B.N-F.M.R.A
	P.E.R.A.
	E.R.A.
	I.S.I.
	B.P.F.
	R.A.B.R.M.
Metals and Alloys:	A.D.A.
aluminium	I.S.I.
ferrous	B.I.S.R.A.
	B.S.C.R.A.
	B.C.I.R.A.
	B.I.C.T.A.
	I.S.M.E.
sheet	Z.D.A.
zinc	Z.A.D.C.A.
lead	L.D.A.
non-ferrous	B.N-F.M.R.A.
tin	T.R.I.
general	F.R.I.
	P.E.R.A.
	M.I.R.A.
	S.P.R.L.
	N.P.L.
Metal Spraying	I.W.
	A.M.S.
Mining	I.M.M.
Noise	N.P.L.
	N.E.L.
Oils and Lubricants	I.S.I.
	I.P.
	P.E.R.A.
	M.I.R.A.
	R.A.S.
Paints	L.D.A.
	B.I.S.R.A.
	M.I.R.A.
	S.P.R.L.
	B.N-F.M.R.A.
	B.S.R.A.
Paper Making	B.P.B.I.R.A.
Plastics	B.P.F.
	S.P.R.L.
	P.E.R.A.
Production Engineering	P.E.R.A.
	I.Prod.E.
Radio and Television	R.R.S.
	B.R.E.M.A.
Refractories	N.P.L.
	I.S.I.
	S.P.R.L.
	B.I.S.R.A.
	B.C.R.A.
	B.G.I.R.A.
	R.A.G.B.
Refrigeration	I.R.
Rubber	P.E.R.A.
	S.P.R.L.
	R.A.B.R.M.
	N.R.D.B.
Shipbuilding Engineering	B.S.R.A.
Sintered Metals	I.S.I.
	N.P.L.
	M.I.R.A.
	L.D.A.
	F.R.I.
	P.E.R.A.
	S.P.R.L.
	B.N-F.M.R.A.
Soldering	T.R.I.
	B.N-F.M.R.A.
	L.D.A.
Springs	C.S.F.R.O.
Standards	B.S.I.
Textiles	B.Cot.I.R.A.
Trade Names	B.E.A.
	B.P.F.
	G.M.F.
Translations	I.S.I.
	ASLIB
	E.R.A.
	P.E.R.A.
Ventilation	H.V.R.A.
	B.R.S.
Welding and Brazing	P.E.R.A.
	I.S.I.
	L.D.A
	F.R.I.
	B.S.R.A.
	B.N-F.M.R.A.
	I.W.
	B.W.R.A.
	I.Prod.E
Wood	T.D.A.
	F.P.R.L.
Zinc	Z.D.A.
	Z.A.D.C.A.

SILICONES IN ENGINEERING

The properties of silicones have opened up new engineering possibilities. This article surveys their role as dielectrics, rubbers, fluids, lubricants, and in paints and release agents

by B. F. W. HAYWARD,* D.F.H., A.M.I.E.E. A.M.A.I.E.E.

THE uses of silicones in various fields of engineering are already so numerous that it is possible to describe only some of the more important applications in an article of this nature. The applications referred to here have been selected to illustrate the basic properties of silicones and the ways in which they are being used to advantage in engineering design. Emphasis has been placed on the higher performance and greater reliability of electrical equipment in which silicones are used for insulation, as almost all engineers make use of electrical power in one way or another and will be interested in this aspect.

Silicones possess unique properties which have opened up new design and production possibilities for engineers. Although they are considerably more expensive than most organic materials, their use is usually specified on economic grounds, either because of savings which can be achieved in the design and production stage or because of the economies which result from greater reliability.

Silicones are polymeric materials based on chains of alternate silicon and oxygen atoms. Silicon-oxygen linkages are also the basis of the chemical structure of glass, mica and quartz, but these materials are brittle and intractable because the linkages form a random network. In the silicone molecular structure, organic groups such as methyl, vinyl or phenyl are attached to the silicon atoms—by varying these organic groups and the ways in which the silicon-oxygen chains are linked together, a great variety of silicone products are made. Silicones owe their good dielectric properties, thermal stability and chemical inertness to their inorganic "back-bone", while their water-repellency and the fact that they are relatively easy to handle and process is due to the organic groups which are present.

Silicone Dielectrics

The silicone products of most interest to the electrical engineer are the resins and elastomers which are combined with glass fibre, mica or asbestos to form a comprehensive range of insulation materials and components. Silicone resin is also used for impregnating electrical equipment and silicone rubber for encapsulating and as extruded tapes and sleeving. Whatever their physical form, silicone insulating materials give long and reliable service when exposed to:

Heat and Cold: Silicone insulants may be considered for operation over the temperature −90 to +300 deg. C. They are included in Class H and C[1] permitting long-term operation at 180 deg. C. and 225 deg. C. Even when disintegrated by long exposures to very high temperatures, silica is produced which is itself a good insulant, instead of carbon, as in the case of organic materials.

Moisture: Water condenses on silicone insulants as discrete droplets which are individually insulated from each other and high surface resistivity is maintained. Their moisture absorption is low and they rapidly dry out from the wet condition.

Voltage Stress: Because of their low electric losses and good corona resistance, silicones can be operated at high-voltage stresses.

Chemical Attack: Silicone insulants are chemically inert and resist the effects of most corrosive atmospheres.

SILICONE INSULATED MOTORS—The extraordinary thermal stability of silicone dielectrics has enabled radical improvements to be made in the performance of electric motors.[2] Designers can take advantage of the increased temperature rises that are permitted with a silicone insulation system in a number of ways, and perhaps the most dramatic of these is the reduction of size and weight which can be achieved. The aircraft electrical industry was the first to take advantage of this, an example being the 400-c/s induction motor made by Rotol Ltd. which drives the hydraulic pumps operating the undercarriage of the Bristol Britannia 300 series. The motor weighs 32 lb. complete with reduction gear and develops 7 h.p. for periods of up to 35 min.

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An order for 135 electric locomotives for South African Railways placed with Metropolitan-Vickers Electrical Co. Ltd. posed a problem concerning the space available for the motors. The 2,200-h.p. 3,000-volt 84-ton Bo-Bo locomotives have to operate on a gauge of 3 ft. 6 in., compared to the standard 4 ft. 8½ in. in Britain. The problem was solved by using silicone insulation and, to quote Metropolitan-Vickers, "With silicone insulation the traction motors can run at higher temperatures with increased ratings, despite their reduced size".

Wherever motors have to operate in high ambient temperatures the thermal endurance of silicone insulating materials finds an obvious outlet. Fans for extracting hot gases utilise Class H (silicone-insulated) motors, for example, as do the motors driving the rams which push clay into the tapping holes of blast furnaces to seal them after tapping is completed. On each reactor face at Calder Hall there are 60 silicone-insulated motors. They drive the reactor control-rod mechanisms and are designed to be capable of operating in an ambient temperature of 100 deg. C.

In many applications the ability of Class H insulated motors to withstand heavy overloads is more important than the fact that they can operate in hot surroundings or can be made smaller than conventional machines for the same power output. Many industrial machines are subjected to considerable load fluctuations, and to meet these conditions a Class A or B insulated motor of sufficient capacity to match the peak loading is usually installed. In these circumstances a silicone-insulated machine rated to match the base load with Class B temperature rise will operate at its optimum efficiency for most of the time, while the thermal endurance of the insulation will carry the overloads. Since Class H materials leave no carbonaceous residue after decomposition, it would be expected that electrical equipment insulated with them would be free from "burn-outs" and this has been substantiated by testing motors to destruction at very high temperatures.[3] The motors finally failed because of open circuited conductors caused by oxidation and not through short circuits ("burn-outs") due to insulation breakdown.

The water-repellency of silicone insulation and, in particular, its rapid recovery of insulation resistance when drying out, are of especial value when motors are located in wet or humid conditions. Such conditions are frequently found in coal mines and during the past six years several hundreds of coal-cutter and conveyor motors have been rewound for the N.C.B. in silicone insulation.

CLASS H AND C DRY-TYPE TRANSFORMERS—Until recent years most distribution transformers have contained oil, but the thermal stability and water-repellency of silicone insulation obviates the need for transformer oil either as a coolant or to keep out moisture.

Silicone-insulated dry-type transformers are designated Class H or Class C according to their temperature rise on full load, and are available at ratings up to 3,000 kVA., 15 kV., either air-cooled or sealed in nitrogen. The fire and explosion risk associated with oil-filled units is eliminated and less maintenance is required. In addition, they show a saving in weight and size compared with the equivalent rating of oil-filled units and are claimed to have high overload capacity.[4]

At present there is a substantial premium on the initial cost of Class H and C transformers compared with oil-filled units, but this can be largely offset by the fact that there is no need for transformer vaults or carbon dioxide equipment and, in many cases, they can be installed on the factory shop floor in order to cut expensive low-voltage cable runs to a minimum. In the Luton factory of Vauxhall Motors, for example, eight 1,250 kVA. silicone-insulated dry-type transformers are used to supply welding apparatus and are mounted in the roof structure, thereby facilitating distribution and saving floor-space.

Type 281 silicone-insulated motors are installed in each of the 135 Metrovick electric locomotives delivered to South African Railways

SILICONE RUBBER-INSULATED CABLES—Silicone rubber is essentially a mixture of a silicone polymer, curing agent and heat-stable fillers. While it is similar in appearance and feel to other rubbers used in cable manufacture, it has unique properties which make it outstanding as a cable insulant. These properties have led to a rapid growth in the demand for silicone-insulated cables in recent years.[5]

The mechanical and dielectric properties of silicone rubber undergo no significant change at temperatures which cause rapid deterioration of organic elastic materials. Accelerated ageing tests and field experience indicate that silicone rubber-insulated cables can operate continuously for several years at temperatures up to 200 deg. C. If long-term service is required in conditions where flexing will be experienced, however, then 150 deg. C. is generally considered by cable makers to be a reasonable maximum temperature for continuous operation and a draft British Standard has been issued quoting this figure. As might be expected, the performance of silicone rubber-insulated cables is not materially affected by the presence of moisture

The ignition system of this outboard motor has been treated with silicone insulating compound to exclude moisture.

The back of this Bratt Colbran rustless steel radiator has been treated with a heat-resistant aluminium pigmented silicone paint made by Atlas Preservative Co. Ltd.

and no special terminations or end seals are required. In addition, these cables show remarkable resistance to corona and weathering as well as to a wide variety of chemicals. Silicone rubber is not fungicidal, but it does not act as a nutrient for fungi and its properties are not affected by fungi that may develop due to nutritious surface contaminants.

When decomposed by very high temperatures, silicone rubber leaves a non-carbonaceous, non-conducting residue of silica. Provided this is held in position, by glass braiding for example, the cable will continue to function. Silicone rubber has for some years been used for aircraft cables and also for all ship wiring purposes in the Royal Navy. In both these applications the ability of the cables to operate through and after fire is of great importance. The Admiralty fire-resistance test stipulates that a length of cable must survive three hours in a gas flame at 750 deg. C., with full rated voltage applied, without undue leakage current.

Silicone rubber-insulated cables find application wherever high ambient temperatures can lead to reduction of the working life of organic insulants. Such conditions are not confined to the more obvious locations such as boiler rooms, foundries, steelworks, etc. Lighting fixtures can often give rise to high temperatures, and it was for this reason that over 11,000 yd. of silicone rubber-insulated cable was installed in the House of Commons in 1950. These cables are also being used, to an increasing extent, for making internal connections in domestic appliances. Their low-temperature flexibility is utilised mainly in aircraft wiring but also proved useful to the British Trans-Antarctic Expedition, as the cables between the cars and trailers were insulated with silicone rubber.

Silicone Insulating Compound—Originally developed during the war for keeping moisture out of aircraft ignition systems, silicone insulating compound continues to be used for this purpose on both civil and military planes. Because of its good dielectric properties, water-repellency, freedom from oxidation and ability to withstand temperatures from −50 to +200 deg. C., a variety of other uses have been found for it.

The compound is grease-like with the consistency of petroleum jelly and it can be applied in thin films by brushing, or wiping, or it may be dispersed in a solvent and sprayed. Water which falls or condenses on a surface which has been so treated will not form a continuous film and high surface resistivity is maintained. This property is of particular interest to transmission engineers, for preventing flash-over on high-voltage insulators and also to post office engineers, to prevent the high leakage currents which can otherwise occur in junction and terminal boxes in wet weather conditions. Other uses include the coating of natural and synthetic rubber components to retard oxidation and prevent cracking, filling transistor capsules and lubricating turret tuners on television sets.

Silicone Rubber

In the section on the use of silicone rubber as cable insulation it was indicated that silicone rubber combines the elastic properties and appearance of organic rubber with the characteristic resistance of silicones to extremes of temperature. Silicone rubbers are mixtures of silicone polymers, inert fillers and curing agents and these constituents are varied to give rubbers which differ both in processing characteristics and final physical properties.

Most grades of silicone rubber are compounded to meet particular requirements, for example:

1. Special stocks for cable manufacture.
2. Grades which can be used intermittently at temperatures as high as 300 deg. C.
3. Grades which remain flexible at temperatures as low as −100 deg. C.
4. Translucent grades for medical and pharmaceutical applications.
5. Grades for sealing applications which resist compression set.
6. Grades which resist the effects of petroleum-based oils, fuels and lubricants.

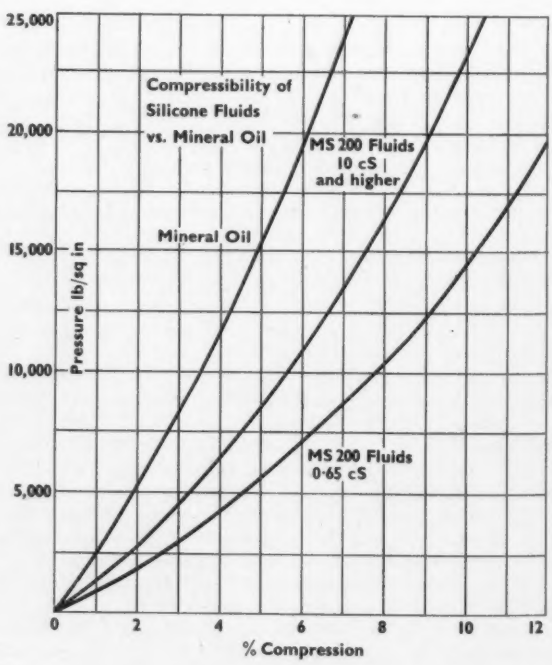


Fig. 1. Compressibility of silicone fluids compared with that of mineral oil.

In general, silicone rubber is most useful where a resilient rubber-like material is required to operate at temperatures outside the capabilities of organic rubbers. In the aircraft industry, for example, uses include hot air ducts, door seals, gaskets and vibration dampers. The heat resistance of silicone rubber is utilised both to lengthen the life and increase the efficiency of many domestic and industrial heating and other appliances.

An unusual property of silicone rubber is that even sticky substances will not adhere to it. It is therefore used for flexible moulds for making toffee, sweets and other sugar products—when the confectionery is cool and set it can be cleanly and easily ejected from the mould. Silicone rubber-coated rollers are used for calendering and embossing plastics films and in the fabrication of pressure-sensitive tapes, and the wax coating of paper. Other ways in which this "non-adhesive" property is employed are for covering pressure plates, press pads and heater jaws for the heat sealing of polythene and other thermoplastics.

COLD-CURE SILICONE RUBBERS—Cold cure rubbers can be converted at room temperature into fully-cured silicone rubbers by the addition of a small amount of liquid catalyst. By varying the amount of catalyst, it is possible, within limits, to predetermine the curing time. Three grades are available, differing in consistency from that of builders' putty to a fluid of a pourable consistency.

All three grades possess the properties characteristic of silicone rubber and can be used at temperatures as high as 250 deg. C. or as low as −50 deg. C. Established applications include encapsulating components against moisture, dirt, oxidation and mechanical shock; making flexible moulds; as a cushioning, caulking or filleting material; as a release agent for moulds or belting.

Silicone Fluids

Of the many desirable properties these fluids exhibit, a number stand out as being important in nearly all engineering applications. Among these are serviceability at high and low temperatures, resistance to oxidation and to viscosity breakdown due to shear, and retention of near-constant viscosity over a wide temperature range. Other attractive properties include low volatility, high flash points and incompatibility with organic oils and polymers. It should also be mentioned that silicone fluids are available in a range of viscosities from 0·65 centistoke to over 100,000 centistokes and that they are non-toxic and non-corrosive.

*TABLE 1. Physical properties of Silastomer**

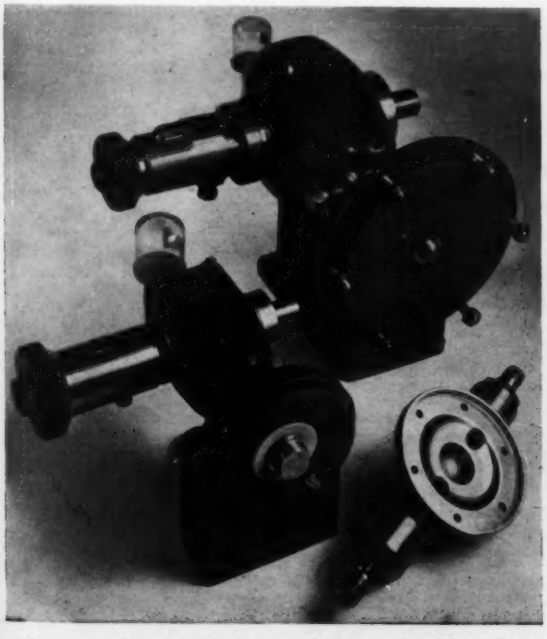
Temperature stability, °C.	−100 to +250
Specific gravity, 25°C./25°C.	1·0–2·0
Hardness, B.S. deg.	40–85
Tension strength, p.s.i.	700–1,500
Ultimate elongation, %	100–400
Compression set, % at 150°C.	10–70
Brittle point, °C.	−110 to −60
Tear strength, lb.	4–15
Electric strength, volt/mil.	250–600
Permittivity at 1 Mc/s	3–4
Power factor at 1 Mc/s	0·001–0·007
Coeff. of cubic expansion (over temp. range 0–100°C.)	0·0007/°C. approx.
Thermal conductivity $\frac{\text{cal.cm.}}{\text{cm.}^2\ \text{sec.}^2}$	5×10^{-4} approx.
Specific heat, cal./gm./°C. (over temp. range 40–90°C.)	0·275–0·325

*Silastomer is a registered trade-mark of Midland Silicones Ltd. Properties were determined at room temperature except where indicated otherwise.

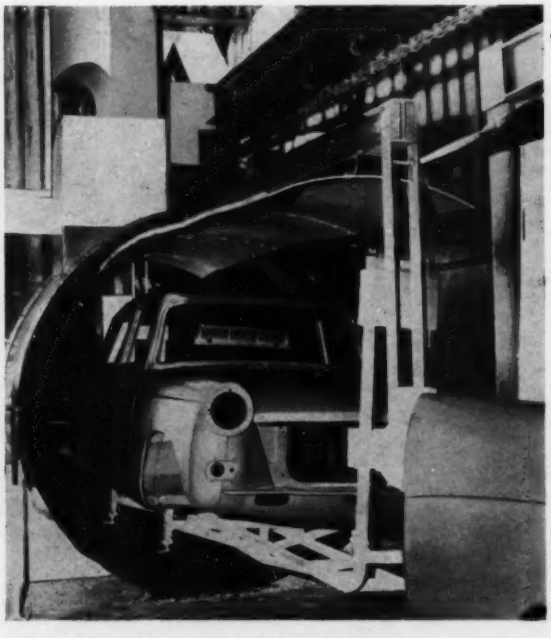
At temperatures used in testing organic oils, silicone fluids of 100 centistokes and higher are virtually non-volatile. When tested at 400 deg. F. for 48 hours, the weight loss of a 35-gm. sample having a surface area of 3 sq. in. is less than 2 per cent.[6] Although low viscosity grades of silicone fluids are quite volatile and have considerable vapour pressure, the vapour pressure of those above 50 centistokes is negligible even at temperatures up to 200 deg. C.

Silicone fluids are much more compressible than comparable organic fluids—especially at high pressures; they are therefore used in liquid springs employed in aircraft undercarriage limits, industrial presses and similar heavy-duty equipment.

In a mechanical device having a fluid component, shear can alter viscosity and thus make the unit inoperable or



Silicone rubber diaphragms are fitted to the E.D.C. diaphragm pump type G.250 V. It can handle fluids from −50 to +250 deg. C.



Silicone grease is used for lubricating the conveyor chains of this infra-red, paint stoving plant installed for the production of Austin cars.

unreliable. Silicone fluids resist the effects of shear, however, even when this is repeated and long term. For example, in a hydraulic system held at 60 deg. C. and 150 p.s.i. the viscosity of petroleum oil fell to about half its original value after 100 hours and 18,000 cycles. In the same system a silicone fluid changed viscosity only 1·3 per cent after 500 hours and 105,000 cycles.

When their low rate of change of viscosity with temperature is also taken into account, it can readily be seen why silicone fluids are being used in torsional vibration dampers. Over a span of 200 deg. F. the damping effect of a high viscosity silicone fluid decreases in the ratio of 3 to 1, whereas that of petroleum hydraulic fluid decreases in the ratio of 2,500 to 1.

Silicone-Based Paints

Paints based on silicone resins have been shown to have excellent heat and weather resistance and are used in industry for many applications where these properties are desirable.[7] They can be broadly divided into three groups:

1. Heat-resisting stoving finishes based on unmodified or 100 per cent silicone resins. Aluminium pigmented silicone paints withstand temperatures as high as 600 deg. C. for long periods. White silicone enamels, which are non-yellowing and non-chalking, give hard finishes which retain their flexibility and gloss for prolonged periods at temperatures which organic finishes will not tolerate.

2. Heat-resisting finishes based on combinations of silicone and organic resin vehicles. Such paints combine the heat resistance and water-repellency of the silicone resins with the desirable properties of such organic resins as alkyds, phenolics, epoxylene and urea or melamine formaldehyde. There is, of course, some reduction in the heat resistance due to the organic content of the paint.

3. Hammer finish coatings using a silicone additive which gives control of the pattern, no variation in pattern over large surface areas, good keeping qualities of the pattern during storage of the paint and reproducibility of the pattern.

Silicone Release Agents

It has already been indicated that silicones have anti-adhesion properties and they have firmly established their usefulness as mould lubricants and release agents in the rubber, plastics, textile and metal casting industries. Being heat-stable, silicone release agents do not decompose to form deposits on the mould and the need for mould cleaning is reduced. A good finish is imparted to the moulded articles which are readily released from the most complicated mould with a consequent reduction in unloading time.

Silicone release agents are available as emulsions, fluids, compounds and resins. In each of these forms they are effective in very small concentrations and are particularly economical in use.

Silicone Lubricants

Silicone fluids and greases compounded with them are useful as lubricants at high and low temperatures and as semi-permanent lubricants at moderate temperatures. There are silicone lubricants suitable for service at −70 to +250 deg. C. They are used, for example, for lubricating conveyors, in stoving and drying ovens, textile equipment operating under hot and humid conditions and aircraft instruments and equipment that have to function over a wide temperature range.

Silicone lubricants should only be used under light to moderate loads and the effectiveness of any particular product varies for different metal-to-metal surfaces. The MS 200 fluids, for example, are good lubricants in either sliding or rolling friction between plain or chrome-plated high carbon steel and aluminium, copper, copper-lead, brass, bronze or tin-base Babbitt. Where sliding friction is involved and both surfaces are ferrous, however, MS 200 fluids have very limited load carrying capacity and better results are given by fluids MS 550 and MS 710.

Even though silicone greases are stable at elevated temperatures, bearing design and construction may have a considerable effect on the life of the lubricant and larger clearances are usually necessary for operation above 120 deg. C. It is quite possible that bearings properly designed and prelubricated at the factory may give trouble-free service for the life of ball bearings used in such applications as blower motors, oil burners and ventilating fans.

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SEARCHING FOR NEW HIGH-STRENGTH ALLOYS

STRONGER alloys, designed to more exact specifications, may be the result of research at the Battelle Memorial Institute; new findings on the strength of experimental aluminium-copper alloys may have application to more complex commercial alloys. The importance of the findings stems from increasing needs for alloys that can be used at extreme temperatures and stresses, as with missile, aircraft and satellite components and modern turbines.

The most important factor in strengthening high-temperature, high-strength alloys is usually the fine metallic particles dispersed throughout the alloys. Until recently it was assumed that the closer the spacing, the greater the strengthening, with the alloy becoming weaker if space between particles increased. Battelle investigations reveal that although increased spacing means increased weakness, this trend reverses itself at a certain point. When spacing is increased to this critical point, strength begins to increase again, reaches a peak with further spacing, and again declines.

For spherical particles in the alloys studied, a maximum strength increase of 16,000 p.s.i. due to spacing effects was found when particles were about 0·003 in. (75 microns) apart. For plate-like particles, the peak increase reaches 23,000 p.s.i. at about 0·0006 in. (15 microns). In both cases, strengthening due to particle spacing begins to decline at greater spacing.

The new findings resulted from using modern quantitative methods to measure the microscopic structure of alloys. These methods can also be useful in many other fields, it is suggested, as in determining the volume per cent of air bubbles in frost-resistant concrete, the characteristics of flakes in paint, the types and amounts of minerals in rocks and the density of sintered ceramics. The value of the methods of quantitative metallography is that they can be used to obtain exact and objective quantitative measurements rather than subjective estimates.

DESIGN PRINCIPLES OF FORGING

Forging is a technique that can produce high strength and other special characteristics in a component. This article presents the basic principles of forging and shows how the designer can apply them most satisfactorily

by R. C. JONES *

SOME causes of difficulty and increased cost can be avoided at the design stage by a better understanding of the basic methods used in forging.

The maximum practicable radii should be allowed. An attempt to save material in machining can result in a more than corresponding increase in forging costs. It is customary, depending upon the size of the forging, to allow from $\frac{1}{16}$-$\frac{1}{8}$-in. cut for machining, where demanded. In instances of extremely long wormshafts, etc., it may be advantageous to allow rather more, as this obviates machining scrap resulting from distortion. See Table 1.

JIG LOCATION SURFACES—For most satisfactory results, all jigging should be done on the least variable surface of the forging. By judicious examination, this may fairly easily be assessed. At all times jigging on or near the parting line should be avoided. In the same way, avoid jigging in a punched hole, as this may be sufficiently eccentric to prevent the outer diameter from cleaning up in machining. Wherever possible, full advantage should be taken of a boss projection or some similar point for the first jig location.

Purchasers of forgings can assist the supplier to a great degree in this respect by indicating on the drawing the intended jig location surfaces.

* *Technical development engineer, Head Wrightson Stampings Ltd.*

FORGING DRAFT—In order that a completed forging may be withdrawn from the dies, it is necessary to provide a positive rake varying from 3-7 deg. on the walls of the impression according to the intricacy of the job. This angle is known as draw or draft. This is a feature necessary to the production of forgings, and to a greater or lesser degree will be in evidence on every drop forging that is manufactured. It may safely be assumed that nowhere will a greater draft angle be called for than has been found by previous experience to be necessary for ease of withdrawal and for a reasonable die life. Fig. 2 illustrates a typical forging where the extent of the draft varies depending upon the form of the impression.

Although 5 deg. is stipulated for external diameters, these could, if absolutely imperative, be reduced to 3 deg., as the hot metal tends to contract away from the outer walls of the die impression, thus affording trouble-free withdrawal.

In the case of internal peg forms, the reverse will apply, as the hot metal will tend to bind on to the peg form, making withdrawal very difficult. For this reason it has been found that a minimum of 7 deg. draft is very desirable and often as much as 10 deg. has to be provided to obviate "sticking" problems.

These products are made on a forging machine by a gripping and squeezing action. Forgings of the type suitable

TABLE 1. Drop forging thickness, surface and offset tolerances (B.S.)

Forgings Group net wt., lb.	Thickness Limits (in.)				Offset Tol. Misplacement of one die (in.)	Die Wear Limits (each surface), in.	
	Standard		Close				
$\frac{1}{2}$	+0·030	−0·010	+0·010	−0·010	0·015	+0·020	−0·005
$\frac{1}{2}$-$1\frac{1}{2}$	+0·040	−0·013	+0·015	−0·010	0·022	+0·030	−0·010
$1\frac{1}{2}$-3	+0·050	−0·017	+0·020	−0·010	0·027	+0·037	−0·012
$1\frac{1}{2}$-5							
3–5	+0·050	−0·017	+0·027	−0·010	0·027		
5–10	+0·060	−0·020	+0·035	−0·010	0·032	+0·044	−0·015
10–20	+0·075	−0·025	+0·050	−0·016	0·037	+0·052	−0·017
20–40	+0·095	−0·032	+0·061	−0·021	0·047	+0·066	−0·022
40–60	+0·107	−0·036	+0·070	−0·024	0·055	+0·077	−0·025
60–80	+0·118	−0·039	+0·079	−0·026	0·057	+0·085	−0·028
80–100	+0·125	−0·042	+0·083	−0·028	0·060	+0·090	−0·030
100–150	+0·140	−0·047			0·062	+0·095	−0·032
150–200	+0·150	−0·050			0·065	+0·100	−0·033

for forging machine production demand a great deal less in the way of draft and fillet radii than do drop forgings, and for pinion forgings in particular continuity of grain flow is an automatic feature of this method of production. Frequently, where the size of the internal machined bore is proportional to the length of material used in the upset, a bar of equivalent diameter is used, thus eliminating any slug wastage when the forging is punched in the final operation.

The three principal laws governing upsetting are as follows:

1. The limit of length of unsupported stock that can be gathered or upset in one blow without injurious buckling is not more than three times the diameter of the bar.
2. Lengths of stock more than three times the diameter of the bar can only be upset in one blow, provided the diameter of the upset made is not more than one and one half times the diameter of the bar.
3. In an upset requiring more than three diameters of stock in length, and in which the diameter of the upset is one and one half times the diameter of the bar, the amount of unsupported stock beyond the face of the die must not exceed one diameter of the stock.

Drop Forging

DISC HUB—The production sequence of an 80-lb. disc hub forging is such that the sectional variation demands careful consideration in the initial die design. To combat the rapid chilling of the thin flange in the forging operation, speedy disposal of the metal from the centre section is imperative so as to ensure that the flange thickness tolerances are maintained. To achieve this objective successfully, mould dies are a vital feature.

To compensate for the distance by which the dies will remain apart in the moulding operation, the overall flange thickness will require reducing accordingly, thus ensuring that only the minimum of excess metal is transferred to the finishing dies.

A flash gutter of adequate depth is required with components of this kind to avoid retarding the final forging operation. Surplus metal at the centre of the mould forging should also be disposed of in the immediate vicinity, and this can be accomplished by providing a generous flash relief in the centre of each peg of the final dies. The completed forging is then trimmed and punched under a 270-ton crank press.

TRACK ROLLER—The production stages of a track roller forging under two 3-ton drop hammers is shown at Fig. 3. The special feature of this particular example is the forging of two collars on the outside diameter, one of which would be undercut by the normal conventions of drop forging. The first illustration shows the manner in which the metal is moulded into a shape suitable for producing the final dimensions.

The lower collar is, in this operation, being produced to within $\frac{1}{4}$-in. of the final diameter; at the same time, the necessary volume of metal is provided on the 7·662-in. diameter to forge the second collar in the final operation. The mould forging is then trimmed and reheated. In the final

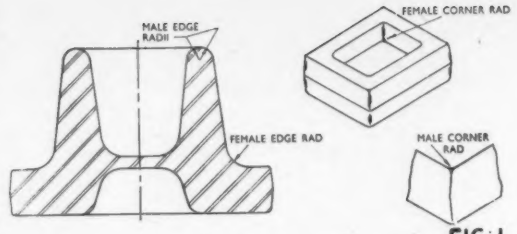


FIG. 1

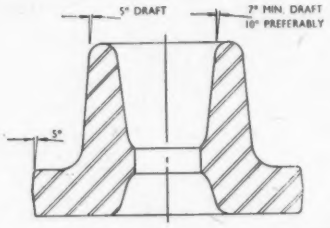


FIG. 2

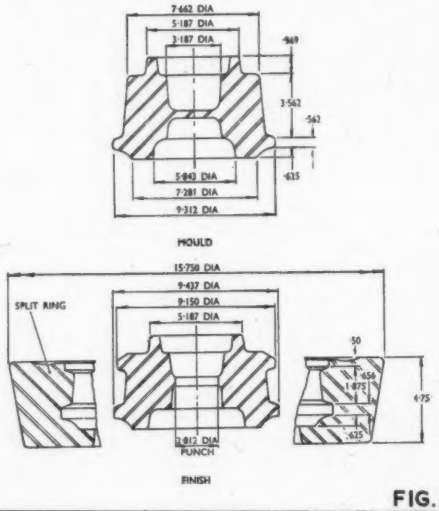


FIG. 3

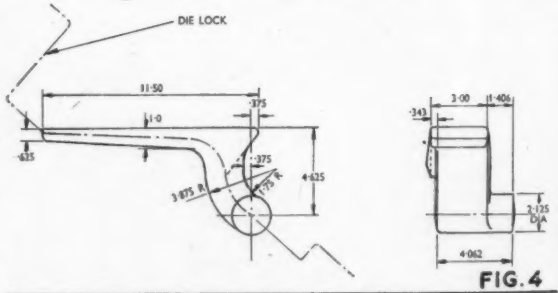


FIG. 4

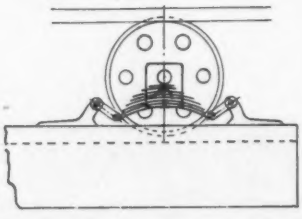


FIG. 5

Fig. 1. In the case of internal peg forms, 7 deg. or as much as 10 deg. draft has to be provided to obviate "sticking" problems.

Fig. 2. Typical forging where the draft varies with the form of impression.

Fig. 3. Production stages of a track roller forging under two 3-ton drop hammers.

Fig. 4. Details of scroll irons.

Fig. 5. Scroll irons form the main spring suspension on the undercarriage of railway wagons.

stage of production the forging is housed in split die impressions, the profiles of which conform to the required dimensions. The split impressions are lowered into position in the mating die by means of a suitable handling device attached, and the additional volume of metal provided, which represents the second collar in the split dies.

Dependent upon the consistency of volume in the cut billet, this second collar can be produced without flash, so that the necessity for a second trimming operation is avoided. The centre bore of the forging is then punched on a crank press.

SCROLL IRONS—Scroll irons, such as are shown in sketch form at Fig. 4, are highly stressed components in that they form the main spring suspension on the undercarriage of railway wagons. This is illustrated diagrammatically at Fig. 5. Formerly, these were produced as castings but a preference has now been expressed to utilise the more resilient characteristics of a forging so as to obviate completely the possibility of failure in service.

Each forging weighs approximately 18¼ lb. and is drop forged in one heat from a cut billet of 22 lb. One hammer is used for the preliminary work of:

1. Reducing the billet by fullering.
2. Flattening the reduced section to cover the foot portion of the scroll.
3. Bending the "use" so formed to comply with the profile of the impression.

The dies used for this preparatory work are shown at Fig. 8. The second hammer is used for the final forging of the scroll iron and, to counteract the back-to-front thrust, a substantial lock is provided on the dies as shown on the forging sketch at Fig. 4.

Upset Forging

AXLESHAFT—In the production of highly stressed parts such as axleshafts for the automobile trade, not only has the steel specification to be held within tight limits, but the method of production also has to be controlled to give forgings of the highest possible quality having the desired grain flow. This is generally best achieved by upsetting from round bar of suitable cross-section to provide the requisite machining allowance on the shaft portion of the component.

In the example chosen the head diameter is 5·375 in. and the diameter of stock used is 1·25 in. By calculation it is found that 19·687 in. of bar is required for the upset, and that in view of the length a gradual transformation has to be effected to ensure that none of the upsetting laws is abused or short-circuited. The omission of any one of the six passes shown in the forging machine dies illustrated at Fig. 6 would jeopardise the ultimate quality of the axleshaft.

Where careful preservation of grain flow is an essential feature, as in the tooth form of intermediate cluster gears, the forging machine has decided advantages over the drop hammer. Not only is the grain structure more uniform, but the forging can also be produced more economically, the flash wastage being considerably less than with a drop forging.

The bar section used is based on the smallest diameter which, in Fig. 7, will be seen as 2·375 in. The 3·625-in.-diameter flange is first upset to finish dimensions in two passes with virtually no flash formation apart from a slight fin between the spline punch and the die bore.

The flange so formed is then gripped in back-stop tongs and the 5·562-in. diameter upset in three passes to give the finished forging sizes. Owing to the permissible variation in rolling tolerances, the bar diameters are liable to fluctuate to some extent, and for this reason it is as well to cater in the die design for a definite flash formation on the periphery of one of the upsets, as this can then be cold trimmed on completion of the final upsetting operation.

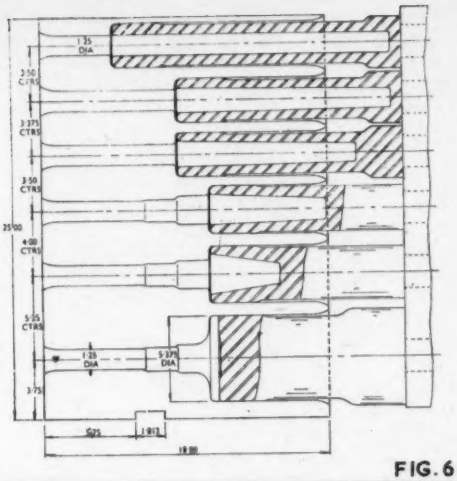


FIG. 6

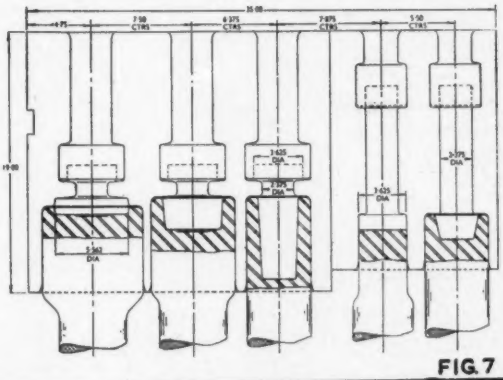


FIG. 7

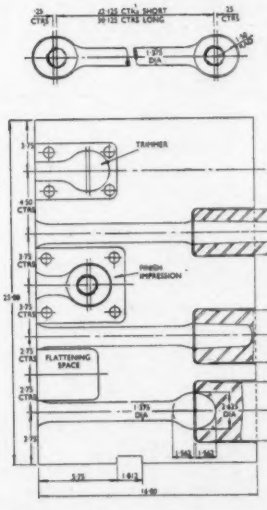


FIG. 8

Fig. 6. Six passes in the forging machine dies for gradual transformation by upsetting from round bar into axleshafts.

Fig. 7. For upsetting, the bar section used is based on the smallest diameter illustrated here as 2·375 in.

Fig. 8. The layout of the dies and punches for a typical shackle forging.

SHACKLES—In the production of railway screw couplings a long and short shackle is required on the completed assembly and, apart from a difference in the overall length, both items are identical. Manufacture on a drop hammer would entail two pairs of dies, and the material section would have to be based on the greatest cross-section. This, in turn, means that the bar requires a considerable amount of fullering before forging the final shape. Not only is this a slow process, but the flash waste on the completed forging is disproportionate to the weight of the job and will be very uneconomical to produce.

By comparison, the forging machine will produce both components from one pair of dies and with very little flash. It may also be assumed that the rate of production will be considerably higher.

It will be appreciated that to justify the additional cost of forging machine dies it is essential, among other features, that the quantities required are substantial.

Fig. 8 shows the layout of the dies and punches for a typical shackle forging. The 1¾-in.-diameter stock is upset in three passes into a sphere, which is then flattened to 1¾ in. on a suitable cutaway in the dies. The "use" is forged to finish dimensions by the clamping action of the moving die, and the slight flash formed around the head is then removed by trimming. The difference in overall length of the two shackles is controlled by a back-stop plate secured to the frame of the forging machine.

Die Costs

When considering the production of a part as a forging, it should not be assumed that, in order to be economic, the full die life quantity must be obtained. The charge for sinking dies which may not be fully used could well be less than the cost of making from solid or using hand forgings or castings.

The life of a die varies with the size and shape of the forging, but averages, in the writer's experience some 2,500 forgings. When a number less than the estimated die life is asked for a price per piece is quoted and, in addition, a lump sum for that part of the cost of the dies by which the inquiry falls short of a full die run.

In calculating the die cost, only that slice of the die block consumed is taken into account. Once a lump sum has been paid in this way, the die is held available for further production of the part at no additional die cost for three years.

Should a production run be called for which is less than that on which the cost was originally estimated, it is sometimes necessary to make a special charge for die setting. Such a charge varies with the size of the hammer concerned.

SYMPOSIUMS UNLIMITED AT A.S.T.M. MEETING

A NUMBER of symposiums covering many diverse aspects of engineering was sponsored recently in San Francisco by the American Society for Testing Materials at its third Pacific area national meeting. Here are some of the points raised during the sessions:

Sandwich Structures

Structural sandwich constructions have been used in considerable volume both in aircraft as well as in building. Because these new materials and constructions lack a long history of service and performance, a number of testing programmes have been established to study the effect of environment and service conditions on sandwich-construction.

At this symposium, laboratory tests on all commonly used types of glass-fabric plastic-core materials were reviewed. A variety of types of sandwich construction and core materials used in an exposure project were also summarised.

An investigation of adequacy of adhesive bonding after field exposure was reviewed, and although laboratory exposures are a valuable tool in evaluating adhesives, field service data are required to back up the laboratory data. The durability of a bonded repair system for aluminium honeycomb structures was given a severe test in the exposure of panels for periods up to two years in the Panama Canal Zone, and there was no evidence of deterioration in the system using an epoxy adhesive.

Temperature rise in structures due to solar heating was described, and suggestions for design of sandwich construction exposed to solar radiation were made. The conclusion that structurally adequate panels with expanded polystyrene core material can be designed and used was based on results from tests of a pilot structure using panels faced with many combinations of facing materials.

"Newer" Metals

The demands for metals in the new environments of nuclear radiation, extreme temperatures and extreme stress conditions, coupled with the need for reliability in these applications has pushed development of the so-called "new metals". A symposium on this topic was held to gather information that the Society could use in writing specifications.

Two types of data are required to rate the newer metals and their alloys: accurate base-line data obtained in the absence of all possible contamination and reliable strength data obtained in the actual service environment.

Fatigue of Aircraft Structure

Recent investigations by several aircraft companies have shown that jet engine noise can produce structural failures in jet aircraft. These failures, usually concentrated in the flap, wing trailing edge, tail and after-fuselage areas, occur as sudden, large-scale skin failures and as extensive cracking during the service life of the aircraft. At the symposium on "Fatigue of Aircraft Structures" a test procedure was described for obtaining basic information that can be used in the design of surfaces for resistance to this sonic fatigue. This method makes use of a jet engine mounted in a test stand which has considerable area behind it. Specimens are subjected to a noise environment in this area closely approximating that on the surface of a jet-propelled craft. Where other tests simulate environment, this test subjects the specimens to the actual service condition. Also, there is no limit to the size of the specimen; entire airplane surfaces have been tested in this way.

Thermal Ablation

The impetus provided by the missile and space programme has started a great search to find suitable materials which, by the process of ablation (i.e., surface particles, layer by layer, turn directly from solid to gas, continuously carrying off heat that would otherwise be absorbed by the material), can offer thermal protection in such areas as nose cones and rocket exhaust housings of space vehicles. Confronted with the problem of developing suitable materials for such uses, researchers soon decided that some means of simulating these conditions in the laboratory would be necessary. Much ingenuity has been displayed in the use of high-temperature flames, electric arcs, molten metal baths, rocket exhausts and the like for studying the ablation process. While a great deal of data have been collected and workable theories of the ablation process developed, qualitative yardsticks for evaluating the ablation resistance of materials are still sought.

OVERSEAS NEWSLETTER

A monthly digest of reports from our foreign correspondents of other countries' current achievements in research and development work

Assessing Ball-bearing Life

It is generally accepted that the life of a bearing can be expressed as:

$$N = \left(\frac{C}{Q}\right)^m,$$

where N = bearing life in millions of revolutions, C = characteristic constant for each bearing, Q = load in kg., m = constant depending on contact surface configuration.

There is no doubt as to the determination of C, but some uncertainty exists about m, which appears to vary from 3 to 4. This is due to the considerable dispersion presented by the results of the fatigue tests and to the fact that the tests are performed at rising, but discontinuous, values of load and speed.

A special test machine developed by Officine RIV di Villar Perosa of Turin in Italy ensures progressive bearing loading as a function of bearing speed. The bearing is driven at 1,000 r.p.m. by an electric motor through a constant-ratio gear. The load is applied by means of a lever system, the weights being displaceable along the lever arm by means of a threaded rod rotated by the bearing motor via the constant ratio gear. The lever arm—and consequently the load applied to the bearing—is continuously variable, the load variation being mechanically locked to the bearing speed. Lever balancing and initial loading are provided by a second weight, and a totaliser mounted at the tip of the threaded rod records the number of revolutions performed by the loading worm, and since the two movements are locked together, the number of revolutions performed by the bearing.

To alter the loading rate between two tests, weight rings are added to or removed from the lever system. Repeated experiments carried out with this machine have led to a re-evaluation of m = 3·83 for ball-bearings and 4·5 for roller-bearings instead of 3·43 and 4 respectively, the values yielded by conventional constant-load testing methods.

Machining Aluminium Cylinder Heads

A new Economatic transfer machine designed and built by Buhr Machine Tool Co., of Michigan, for machining die cast aluminium cylinder heads for one of the new compact cars, illustrates how the small cars and lighter weight alloys will affect machine tool design.

The ease and speed in working aluminium as compared with cast-iron was considered during preliminary design work, and, as a result, the machine has a number of new features which result in a clean design leading to medium-high production, high reliability, and easy tool and machine maintenance.

Operations consist of complete drilling, chamfering, boring, reaming and tapping. For this, the machine has seventeen working and idle stations, and is separated into two sections by a 90-deg. turn-around.

The operator manually loads a cylinder head at Station 1 and the machine automatically processes the part on a 19-sec. cycle. Control of the two sections of the machine is integrated so that parts pass from one to the other without interruption.

All the cutting tools used on this machine are specifically designed for cutting aluminium, and are operated at higher speeds and feeds than would be the case with cast-iron.

With die castings, many holes are cored. This does not, however, substantially reduce the number of operations as might at first be expected, as drills are run through the holes to make sure they are clean. This is justified because 100 per cent inspection of the parts for correct hole size and shape would otherwise be required before finishing or tapping.

Forming Castings by Capillary Forces

Soviet technicians have recently adapted the method of forming castings to make use of capillary effects.

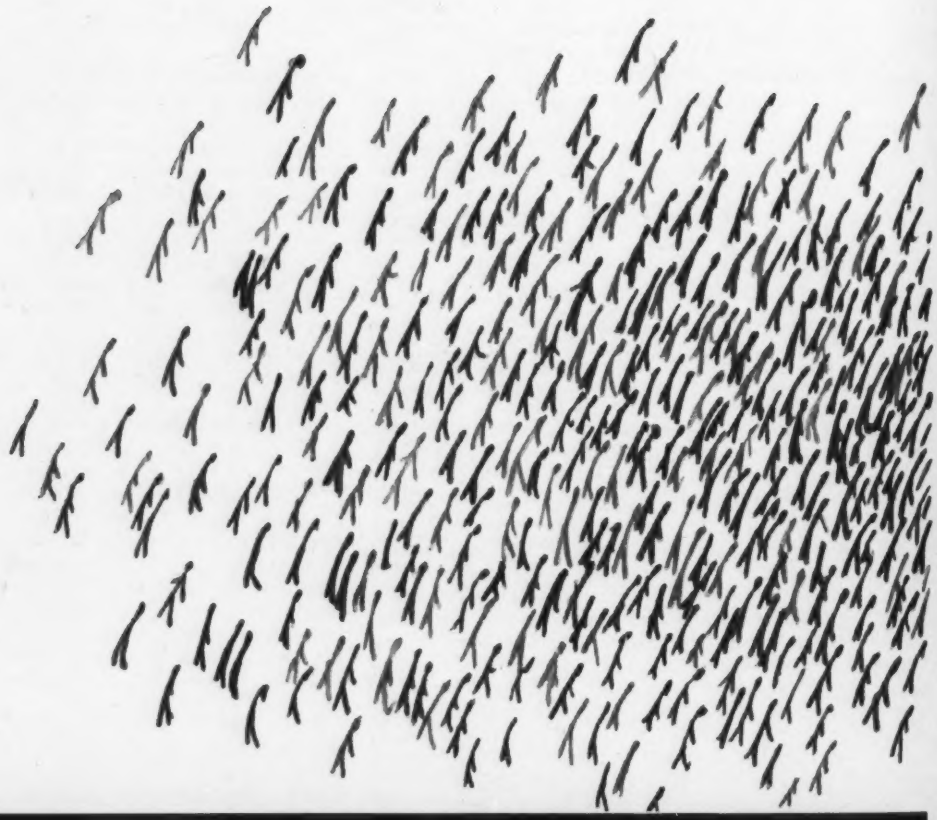
A plate made of a material, inert to molten metal, is placed on top of the melt. This plate, called the moulding float, has a through-slot of a shape and size corresponding to the cross-section of the component to be formed. A priming plug, shaped to fit the slot, is lowered into the molten metal through the slot. When the plug is withdrawn, metal adheres to it and is drawn by capillary forces. After reaching a region of lower temperature, the metal freezes, first crystallising at the edge of the plug and then throughout the raised portion.

It is possible to adjust the cooling and rate of motion of the solidifying metal so that a component will be continuously drawn from the liquid in the form of sheet, rod or tube. The rate of the process is determined only by the rate of heat removal in crystallisation.

Interesting possibilities such as curvilinear and helically twisted components may be realised due to the easily yielding condition of the metal when its shape is actually formed and the freedom of motion of the priming plug relative to the moulding float.

This is the Buhr Economatic transfer machine designed for machining die cast aluminium cylinder heads.

EMD 2331 for further information



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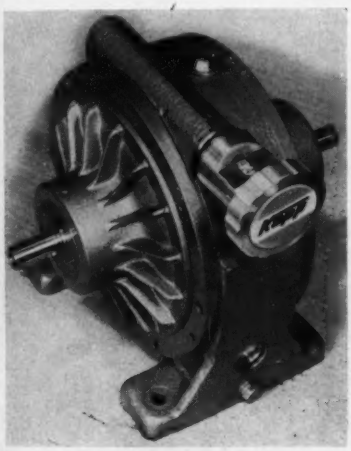
WHAT TO SEE AT THE Engineering Materials and Design EXHIBITION

Earls Court, February 22-26

Allspeeds Ltd. will be exhibiting their range of Kopp variable-speed gears which are available from 1/33 to 15 h.p.

Recognized as one of the most successful of the many friction-type variable-speed mechanisms, all units have a stepless speed variation of 9 to 1 (⅓ to 3 times the input speed) and transmit constant power throughout their output speed range.



A Kopp variable-speed gear made by Allspeeds Ltd.

The new counter-type indicator which is calibrated to one decimal point, enabling set speeds to be repeated with exceptional accuracy, is now a standard fitting. Models to be shown include units (a) with free shaft ends, (b) with flange-mounted motors, and (c) with built-on reduction gears.

A recently developed unit specially designed for vertical mounting fitted with built-in oil sump and pumped lubricating system will also be shown. Particular attention has been paid to avoiding any oil leakage from the lower shaft without relying on any form of seal which is liable to deteriorate in service. (Oakenshaw Works, Clayton-le-Moors, Accrington.)

The metals division of the **Atomic Weapons Research Establishment** at Aldermaston is presenting for the first time an exhibition stand devoted solely to beryllium. The stand will show how this very light but extremely rigid metal is obtained, together with a large number of samples of products made from it, including cast, sintered, fabricated and machined beryllium pieces. It will show their current and potential applications, ranging from aircraft disc brakes (which are based on beryllium's high heat capacity) to reactor fuel element cans for the advanced gas-cooled reactor at Windscale (which can take advantage of its low neutron capture properties).

The main emphasis will be on the important part A.W.R.E. is playing in investigating and overcoming the metal's peculiar brittleness. Work has followed three main lines of investigation, these being the effects of impurities, grain size and crystal orientation.

A.P.V.-Paramount Ltd. are exhibiting castings in a wide range of their Paralloy stainless, heat-resisting, carbon and special alloy steels. This company is producing steel castings to meet the special quality demands made by the nuclear energy, chemical, petroleum and processing industries, and castings are shown for many applications within these industries.

Of particular importance is a display of the range of Paralloy "Forging Quality" cast stainless-steel pipe fittings produced to the British and U.S. standards employed in the petroleum, chemical and nuclear engineering industries. These cast fittings are directly interchangeable with their wrought counterparts for high-

Paralloy Forging Quality cast stainless-steel pipe fittings.

pressure service, and have been accepted by the leading petroleum companies as such. (Manor Royal, Crawley, Sussex.)

Sintered metal parts can be characterised by their use as self-lubricating bearings, either by being impregnated with a suitable lubricant, or by achieving a matrix containing p.t.f.e. or graphite. **Bound Brook Bearings Ltd.** will be exhibiting examples of these under the name of Lubrook (oil impregnated), Polyslip (p.t.f.e) and Bound Brook (graphite). For the designer, there will be considerable information on the correct design and tolerances for fitting and their mechanical properties and production runs as related to cost saving.

The company will also be showing examples of Ferrocite sintered components with a choice of several standard forms of iron alloys, each with a controlled specification enabling engineers to meet the requirements of a wide range of applications. A further advantage with this material is that it may be hardened and tempered and then impregnated with a lubricating oil (which also protects against corrosion). (Trent Valley Trading Estate, Lichfield.)

A 100-ft.-long Dracone flexible barge made from an immensely tough proofed nylon fabric is the focal point of the display by **British Nylon Spinners Ltd.** It is the first one to be shown in an exhibition. The version to be seen has a capacity of about 40 tons, but bigger ones, 200 ft. long and with a capacity of about 300 tons, are under development.

Other examples of nylon applications at the exhibition include inflatable buildings and collapsible tanks. Buildings measuring 100 × 40 × 20 ft. high have already been demonstrated successfully, and collapsible tanks are being produced in a variety of sizes from 1,000-10,000-gal. capacity, with even larger ones under development.

Collapsible containers made from rubber reinforced with nylon will be seen on the B.N.S. stand.

Another interesting item is a new type of cargo loading net composed of slotted nylon webbing weighing only about 25 lb. but capable of lifting 2 tons with safety. Other items on show include new types of conveyor belting which incorporate nylon for greater toughness and durability. (Pontypool, Mon.)

The **British Welding Research Association's** stand will emphasise one aspect of the Association's work: the correct design of welded components. To obtain full economic advantage from welding, with safety, designers must ensure that the welds are fully and correctly specified on drawings and must pay attention to a few simple but important requirements. Some of these are illustrated by four simple sets of model structures. One shows the detail commonly used for attaching branch and reinforcing plate to a cylinder—one weld is often almost inaccessible. An improved detail is shown which allows better access for making the welds, and also a very much simplified arrangement with no reinforcing plate which has been shown by research to be better than the conventional method and uses considerably less material.

The other models show the right and wrong detail designs for heavy plate girders, such as crane gantry girders; for intersecting girders used, for example, in welded entablatures; and for a fabricated bearing pedestal. (Abington Hall, Cambridge.)

Technical books of high quality covering a range of subjects will be shown by **Chapman & Hall Ltd.**, who have recently been appointed agents for the U.S. publishing houses, Consultants Bureau Inc. and John F. Rider Inc. The former specialise in translations of Soviet textbooks and periodicals. The Rider manuals are of special interest to students and younger engineers. (37 Essex Street, London, W.C.2.)

Coated strip is finding increasing fields of application in many diverse industries, and shows decided advantages both in cost and in utility. **Coated Strip Ltd.** are showing a range of these applications and the display demonstrates the ability to form the material without destroying either the surface or the adhesion.

The most commonly used materials are steel and aluminium of all tempers other than the very soft, and sizes up to 16 in. wide with a thickness range between 0·004 and 0·04 in. may be treated in practically any colour. Colour may be applied to one or each side, and in the latter case different colours can be applied. (Brockhurst Works, Bescot, Walsall.)

The main function of the drafting machines and drawing tables exhibited by **Dargue Bros. Ltd.** is to combine in one instrument the uses of drawing board, tee square, set square, protractors, scale rules, adjustable set squares and at the same time mount these on an apparatus which enables the draftsman's eye always to be at the correct distance and inclination from the drawing surface. The most modern apparatus to give this function is the Hydraulic 3D Hydrolift drafting stand which enables the drawing board to be moved in three planes by means of pressing pedals and operating a simple centralised lever.

Dargue combined drawing table and desk.

As a further addition to the range, and on show for the first time, will be a writing desk which can be converted into a vertically mounted drawing board in 10 sec. Another new product is a filing cabinet in which drawings are hung vertically and may be pulled out on telescopic slides. Also on show will be cabinets and equipment finished in the latest striped sapele and plastics finishes. (New Simplon Works, South Parade, Halifax.)

The special alloys division of **Dewrance & Co. Ltd.** will be giving demonstrations of the TLB metal powder deposition process in addition to hardfacing by more conventional methods. The powder method is of considerable interest, as it is more flexible than rod deposits, and more adaptable to automatic control, particularly in relation to thickness, which has a direct bearing on cost saving. Various alloyed powders containing chromium, iron, silicon, boron and nickel can be used, and these are available in grades according to particle size.

In addition, a range of high-temperature brazing alloys will be shown with samples of work carried out by various users.

Not the least important item on this stand will be a range of high alloy castings which offer extreme resistance to abrasion and corrosion with ultimate strengths ranging from 55,000-120,000 p.s.i. These particular steels find a variety of uses for heavy duties in the steel industry, in the motor industry as valve seat inserts, and as grit blasting nozzles in foundries. (Great Dover Street, London, W.1.)

Plastics coatings have brought the designer benefits in anti-corrosion methods; an active company in this field is **Durable Plastics Ltd.**, whose stand will highlight their new large-capacity plastics-coating plant. With this will be displayed steel structures that have been coated with heavy deposits of p.v.c. and polythene, to give permanent protection against corrosion. This new plant, said to be the largest in Europe, can handle articles up to 5 tons in weight and sizes up to 7 x 7 x 17 ft. long. (Woodbridge Industrial Estate, By-pass, Guildford, Surrey.)

The **Distillers Plastics Group** (British Geon Ltd., British Resin Products Ltd. and Distrene Ltd.) are showing a wide range of industrial products made from synthetic resins, plastics materials and nitrile rubbers. The use of rigid p.v.c. in the manufacture of ventilation ducting is the main feature of the display, and one of the exhibits will be a scale model made by Extrudex Ltd. of a plating shop showing this ducting in use. Also shown on the stand are several exhibits illustrating the use of Hycar oil-resistant rubbers in engineering; these include oil seals, gaskets and O-rings, oil-resistant conveyer belting and a fuel tank.

Rigid Geon p.v.c. (British Geon Ltd.) was used for the hoods and acid exhaust ducting of this plant at Mullard Ltd.

The uses of Rigidex high-density polythene will be illustrated, and Rockite polyester dough moulding compounds will be prominently featured. These Rockite compounds possess high mechanical strength, heat resistance and electrical properties. Recent developments in pitch/epoxy resin formulations are also to be shown. An interesting item on display will be a farm milk storage tank with a stainless-steel liner fitted within a hollow reinforced plastics shell. (Devonshire House, Piccadilly, London, W.1.)

A wide variety of Fibreform mouldings can be seen on the stand of **Fibre Form Ltd.** Among them will be found T.V. receiver backs and portable T.V. receiver cases, suitcase shells, nursery trays, meter housings, instrument cases, moulded drawers and work trays, giving a good indication of the increasing use of this material.

Some of the characteristics of Fibreform mouldings are readily apparent: their extreme lightness, their strength and particularly their high impact resistance. It will also be noticed that Fibreform mouldings can be finished in many attractive colours, by paint sprayed on or a p.v.c. foil bonded to the moulding. Other features which render Fibreform mouldings eminently suitable for an enormous range of industrial applications are not so immediately apparent and merit further explanation.

John Harper & Co. Ltd. will display a wide range of the fine-finish castings provided for many different industries. Emphasis will be on the suitability of grey iron castings, Harper Meehanite castings, and Harper S.G. iron castings; the display will show how modern developments in foundry metallurgy and techniques enable exceptionally close dimensional and material specifications to be maintained so that designers can confidently use castings and in many instances achieve savings over alternative methods. (Albion Works, Willenhall, Staffs.)

The main feature of the exhibits by **J. J. Harvey & Pressurecast Ltd.** is the firm's production of reinforced glass components with special emphasis on the contact moulding tools for glass fibre production. A feature is made of the firm's ability to produce small quantity jobs and also special requirements in glass fibre. There are also exhibits of epoxy patterns, pressure cast pattern plates, shell moulding pattern equipment, matched metal dies, wood models, and wood and metal pattern equipment. Aluminium castings can be machined if required. Shaping, engraving and copying machines are exhibited, for which the firm are agents. There are also components machined from densified wood and plastics and formed tools for vacuum forming p.v.c. (Lime Bank Street, Manchester, 12.)

ENGINEERING MATERIALS AND DESIGN will be the main feature on the stand of its publishers, **Heywood & Co. Ltd.** Typifying the extent of its range of interest, there will be models of an energy storage unit, a man-powered aircraft and other intriguing mechanisms. Also to be shown are other Heywood technical journals (i.e., *British Communications and Electronics* and *British Chemical Engineering*) together with a selection of technical books of interest to the design engineer.

Three divisions of **I.C.I. Ltd.** will be exhibiting. The Dyestuffs Division will feature synthetic resins (polyesters and polyethers) and polyisocyanates for the production of rigid and flexible polyurethane foams. These are used for pipe, roof and wall insulation, door filling and packaging. The Metals Division, with Imperial Aluminium Co. Ltd., are to show copper, aluminium, titanium, zirconium, a range of the "new" metals, nuclear fuel cans, special copper alloys, "Integron", "Tube-in-Strip" and heat-transfer sheet. The Nobel Division will be showing silicone rubbers and resins for mechanical and electrical work, silicone heat-resistant paints, lubricants for high- and low-temperature uses, mould-release agents and antifoam agents. (Imperial Chemical House, Millbank, London, S.W.1).

Insley Industrial Supply Co. Ltd. are exhibiting their wide range of Nadella needle bearing, needle bushes, high-duty cam followers and "super-slim" needle thrust bearings. With the inherent advantages of lightness in weight, high load carrying capacity and compactness, these bearings are becoming increasingly popular with design engineers, as they allow performance figures to be improved without incurring the penalty of increased size and weight.

The high-duty cam followers in particular are proving of immense value in modern automatic machinery, due to their capacity to withstand heavy shocks and loading without frequent attention. "Super-slim" needle thrust bearings, no thicker than a washer and capable of taking heavy thrust loads at high speeds, will be on display. A unique feature of these bearings is the incorporation of the raceway on one side of the needle cage. Special high-precision versions of this range of bearings are available for machine tool applications.

Super-thin needle thrust bearings no thicker than a washer will be seen on the Insley Industrial Supply stand.

Also on show for the first time are the Nadella Delta super-precision needle bearings, which incorporate a patented method of radial play adjustment. (21-22 Poland Street, London, W.1.)

A further development in the design of needle bearings is exemplified by the products of **Ina Needle Bearings Ltd.**—in particular, the guided needle type. On show will be a complete range of these bearings together with several examples of their application in various industries.

One of the more interesting types is the self-aligning needle bearing which is available with or without an inner race, and allows for limited misalignment of shafts. (Dafen, Llanelly, Carms.)

Meehanite metal is a high-duty cast iron produced in various types to suit a wide range of applications and is manufactured to rigid specifications. Close metallurgical control of physical properties assures a guaranteed product of known properties. On the stand of the **International Meehanite Metal Co. Ltd.** will be comprehensive literature illustrating the wide range of uses for castings and information on interesting applications involving special properties. (Meerion House, 4 Downside, Epsom.)

With the increasing tempo of design, it is often desirable for a proportion of design work to be contracted out to design consultants. One of the largest groups of consultants in this field is **E. G. Irwin & Partners Ltd.**, who will be exhibiting some of the specialised equipment for which they have been responsible. Much of the work carried out for the U.K.A.E.A. is necessarily secret, but it is expected that photographs of remote control handling machines being designed for the new irradiated fuel element facility at Windscale will be shown.

To illustrate the size and diversity of their design organisation, many other examples of both large and small industrial projects will be shown, together with some of the intricate problems which have to be tackled. (2 Princes Row, Buckingham Palace Road, London, S.W.1.)

The uses of precious and semi-precious metals will be typified by examples shown on the stand of **Johnson, Matthey & Co. Ltd.** The exhibits emphasise the diversity of engineering fields which include chemical, electronic and nuclear engineering, and welding. Of particular interest in instrumentation are the platinum metals for resistance thermometry and the precision drawn tubing for Bourden gauges and capillary tubes. The rare earth metals feature largely in atomic engineering, and samples of these will also be shown.

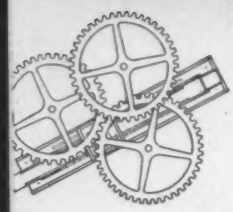
Other exhibits will include bursting discs, catalysts and spectrographically standardised substances. Not the least interesting are the components in the electrical field using silver-gold for metallising and cobalt-platinum magnets. Semiconductors are also well represented. (73-83 Hatton Garden, London, E.C.1.)

Knitmesh Ltd. are to show some typical industrial applications of their product, Knitmesh, which, as its name implies, is a mesh structure of asymmetrical interlocking loops knitted from metals or plastics. The special characteristics are largely due to its mechanical properties and to the very large range of materials from which the mesh can be made. The most usual materials are plastics, such as nylon, p.v.c. and polythene, and metals such as aluminium, Monel, stainless steel, nickel, copper and galvanised steel, but other materials are used to meet special requirements.

Applications are found in industries with problems of filtering, electronic shielding, cushioning, heat exchange and the removal of entrained gases. A more recent application is in vibration control, making use of the resilience of the tiny springs formed by the loops of wire in the mesh. (36 Victoria Street, London, SW1.)

The production of steel and iron castings in the multitude of specifications made necessary by the onerous conditions catered for by the engineers of today is a field in which the British foundry industry has long excelled. In addition, these requirements have necessitated the constant development of new production techniques to keep pace with these demands. **Lake & Elliot Ltd.** offer production of specialised castings in carbon steels, alloy steels, stainless steels and heat-resisting steels to B.S. and A.S.T.M. specifications, in addition to iron castings to B.S. 1452 and S.G. iron castings to B.S. 2789, with the added service of designing castings and producing finished machined products to clients' particular specification. (Braintree, Essex.)

In addition to the commercial grades of copper, nickel alloys and stainless steels, **Langley Alloys Ltd.** produce a number of alloys with specially developed



properties for conditions where they are needed. Their stand will display applications of some of these and will indicate how the co-operation of the designer and the material manufacturer can best exploit their properties.

The exhibits will also indicate ways in which engineering problems have been overcome by using material processing methods, such as stamping and shell moulding, and how these can result in production costs. In another exhibit the advantage of using shell-moulded stainless-steel castings will be indicated. (Slough, Bucks.)

Heat- and abrasion-resisting steels and precision castings form the main theme of the display by **Lloyds (Burton) Ltd.** These are now being made for a wide and growing range of engineering services, and in many cases provide an answer where components would otherwise prove uneconomical or impractical.

The latest developments include heat-resistant centrifugally-cast tube, and precision castings to close dimensional accuracy and fine surface finish for the die casting, precision engineering and rubber industries. The company advise, design, produce, test and machine steel castings for any specified service condition. (Wellington Works, Burton-upon-Trent.)

Low Moor Alloy Steelworks Ltd. will include in their display a comprehensive range of stainless steels produced to meet almost any known requirement of industry, high-speed steels and tool steels, and valve steels for I.C. engines. In addition, L.M.A.S. super-Hiperm is expected to create considerable interest by reason of its wide field of application, being suitable for the manufacture of motor and generator field frames, pole cores, clutch plates, magnetic chucks, yokes, telephone and other communication system parts. A full range of drills, reamers, tool bits, milling cutters, etc., will be included in the exhibit.

A wide range of steel sections has been successfully extruded and a comprehensive selection of these will be on show to indicate the extensive applications possible. These extrusions are produced in all types of steel from mild steel to the most complex alloy, stainless, heat-resisting and high-speed steels, and their use can offer many advantages by eliminating or extensively reducing expensive machining operations or complicated fabrications by welding, etc. (Low Moor, Bradford.)

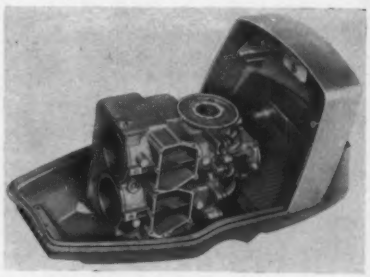
Ceramics have made an important contribution to engineering technology. Sintox, produced by **Lodge Plugs Ltd.**, is a versatile ceramic with high electrical resistivity, high thermal conductivity, mechanical strength, hardness, superior chemical properties and low neutron-capture cross-section. Of the alumina type, its application may be found in voltage regulators, fire detection systems, argon arc welding torches and in textile machinery. Cutting tools may also be included in these applications. Grades of Sintox are produced in complex shapes to tight dimensional tolerances. (Rugby.)

Although some of the more exotic metals may claim the attention of the designer, research and development still proceeds with conventional ferrous and non-ferrous materials with a view to still further improving their properties and manufacture. **Macready's Metal Co. Ltd.**, who, as steel stockists, have the opportunity of dealing with many different steels, hold considerable stocks of bright steel flats, silver steel, ground flat stock and oil hardening tool steels to many specifications, and are able to offer to industry a first-class delivery service by reason of their large transport fleet. Particular emphasis is laid on the service available to the manufacturer of repetition turned parts to order by the availability of Usaled, a lead-bearing free-cutting steel, super lead-bearing and Usaspead Super free-cutting steel. The range of sizes from stock in hexagon section covers the full unified thread series as well as the normal B.S.F./B.S.W. and metric sizes; also included are the normal fractional sizes. (Pentonville Road, London, N.1.)

The use of high-strength materials in present-day engineering is synonymous with the need for alloys which will withstand high temperatures, at the same time having good corrosion resistance. **Manganese Bronze & Brass Co. Ltd.** have developed a range of copper-based alloys in the form of aluminium bronzes and manganese bronzes which fulfil these requirements. Details of these and other non-ferrous alloys in extruded, rolled and forged condition will be available at the exhibition.

Shown also will be a range of bearings and parts produced by powder metallurgy in both ferrous and non-ferrous metals under the registered trade-mark of Oilite. While the alloys offered have no particular claim to high-temperature and corrosion resistance, their unique self-lubricating characteristics enable them to fulfil applications where bearings are placed in inaccessible positions, but it must be emphasised that these Oilite bearings and parts will function very successfully as a direct replacement of most conventional solid bronze bearings and components—usually at a considerable cost saving. (P.O. Box 19, Ipswich.)

As a contribution to the growing popularity of power boating, a new Perkins 34-h.p. diesel outboard motor unit has recently appeared on the market. The accompanying photograph shows the cylinder block, crankcase and power housing for this engine and represents a remarkable achievement in pressure die casting by **J. V. Murcott & Sons Ltd.** Produced in four sections, the aluminium parts require a negligible amount of machining due to the high quality tools and dies designed and manufactured within the company. In addition to pressure die castings in aluminium and zinc-base alloys, the company are patentees of a unique method of making hollow aluminium pressure die castings suitable for components such as cylinder heads which contain air and water passages. Very close tolerances for wall thicknesses can be achieved by using this process. (Grosvenor Road, Aston, Birmingham, 6.)



Cylinder block, crankcase and power housing for the Perkins outboard motor; other die castings of this kind will be shown by J. V. Murcott & Sons.

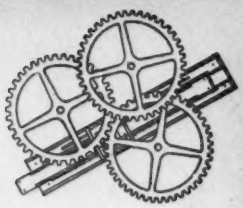
One of the most interesting applications of plastics is shown by the nylon marine propeller on the stand of **Nylonic Engineering Ltd.** This material offers considerable advantage in the marine world, and other examples of the application of plastics are also being shown. Unusual forms of raw materials in the shape of tubes, rods and sheets are shown by examples in polypropylene and polycarbonates of tubes of 8 in. dia. and sheets up to 3 in. thick.

Samuel Osborn & Co., steelmakers, steel founders and engineers' tool makers, are exhibiting on their stand the following products:

Steel castings by the precision methods of the Shell Mould, Osborn Shaw and Osborn CO_2 block processes; extruded steel sections; titanium products, special corrosion- and heat-resisting alloys—the application of which is illustrated by models of a heat exchanger and cut-away pump for handling corrosive liquids; stainless steels and tool steels, etc. (Clyde Steel Works, Sheffield, 3.)

The exhibits on the stand of **P.I. Castings (Altrincham) Ltd.** are largely divided into two groups: (a) investment casting production by the Picast process, and (b) the application of Picastings to machinery and equipment.

That part of the stand which deals with the production side was in fact awarded the Educational Award of the Purchasing Officers Association Minibition in 1959, and is essentially educational in that the various stages of production are featured in the form of die equipment, wax patterns, moulds and castings for one particular component: the component is shown in conjunction with other items produced as investment castings and incorporated in a mechanised artificial arm.



The section dealing with the application of Picastings has as its focal point a knitting machine which incorporates some 400 investment castings. Sub-assemblies of cam boxes and lever controls are shown in conjunction with the exhibits, and the economic advantages of extensive use of the process are indicated. (Atlantic Street, Altrincham.)

A wide selection of various plastics will be shown both as raw material and as typical manufactured items by **Polypenco Ltd.** Nylatron GS is a molybdenum disulphide-filled Nylon 66 supplied as an injection moulding powder, extruded shapes and machined components to requirements. Nylasint, being a sintered nylon, provides superior wear and frictional properties with outstanding dimensional stability for moulded parts.

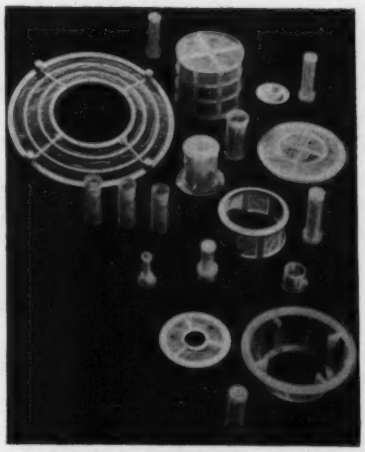
Other exhibits will be Makrolon polycarbonate thermoplastic, a chemically inert chlorinated polymer known as K 51 Penton, and a selection of high-pressure polyamide tubing and braided hoses in a wide range of sizes and known as Nylaflow. Examples will also be shown of the uses for Fluorosint, a p.t.f.e.-based material. (68-70 Tewin Road, Welwyn Garden City, Herts.)

Precious Metal Depositors Ltd., in association with P.M.D. Chemicals Ltd., are well established in the electronics industry for their gold and silver plating of contacts, printed circuits and microwave components, while P.M.D. are known as manufacturers of the Alchromate treatment for aluminium and its alloys; this finish is designed specifically for the electronic field, and provides a climatic protection for aluminium and at the same time is electronically conductive.

On the stand will be a demonstration of the Alchromate process, as well as an immersion gold-plating process for printed circuits, this latter enabling gold to be applied to silver. (Hearsall Lane, Coventry.)

The use of plastics extrusions and mouldings can greatly assist a designer to achieve a balance of efficiency and appearance, and the wide variety of plastics offers a choice suitable for many different conditions. **Plastic Engineers Ltd.** will be exhibiting a wide range of their products showing some of the advantages. Of particular interest are their nylon strainers and filters which indicate an economical advantage over the use of more conventional materials. Marketed under the name of Strylon, these units are moulded in one piece to combine frame, filter mesh, gaskets and threaded unions. (Treforest Industrial Estate, Nr. Pontypridd, Glam.)

Wood, in various modified forms, today continues to play an important industrial role. **Prestfibre Ltd,** specialise in compressed fibre mouldings which offer a cheap, strong material for the mass production of many articles. The process employed is particularly suited for large products. Deep mouldings with parallel vertical walls are possible and the thickness may be varied from $\frac{1}{16}$ to $\frac{1}{4}$ in., the density being adjusted to requirements. Typical products to be shown are cabinets for T.V. sets, motor car facias, tape recorders and record players, showing the various finishing treatments possible. (359 Canal Road, Bradford, 2.)



Examples of nylon filters which will be shown by Plastic Engineers Ltd.

Ceramic materials possess excellent insulating characteristics, a low coefficient of friction and are highly resistant to abrasion. Of the high-alumina ceramics, Regalox brand, produced by **Royal Worcester Industrial Ceramics Ltd.**, is used to a very large extent in the electrical, chemical and textile industries, and finds a place in many other types of engineering, examples being plug gauges, drill bush liners, pump seals and high-temperature furnace equipment. The finished component can be obtained in almost any shape with a high surface finish, and can be produced economically to very close tolerances.

In addition to the Regalox brand of ceramic, the company are also producing a non-felspathic porcelain for carbon rod manufacture and for electrical installations of all types. (Tonyrefail, Glam.)

Recent advances in the metallurgy of iron has resulted in this material finding entirely new applications. One is the increasing use of spheroidal graphited iron, and the stand of **S. Russell & Sons Ltd.** will be exhibiting examples where this material has been used. With these will be included detailed information to enable designers to use to the full all the inherent advantages of S.G. iron.

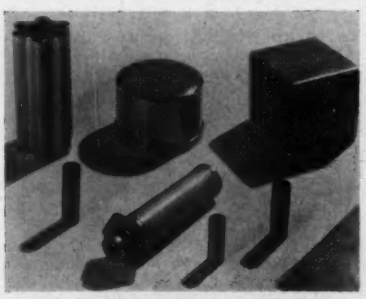
Other items on show will include high-quality castings in grey iron, high-duty and alloy irons, many of the latter being of the S.G. type. (Bath Lane, Leicester.)

Ruston-Grayloc high-pressure pipe connections will be the principal exhibits on the **Ruston & Hornsby Ltd.** stand. These connections employ sealing principles entirely different from those of other seals, are lighter and smaller than conventional bolted flanged connections for a given duty, and can be made and broken rapidly and repeatedly. Once the surface has been made, the connection will withstand high internal and external pressures, as well as vacuum. When high internal pressures are applied the sealing force is increased.

There is said to be no significant differential thermal expansion or contraction throughout the connection and no resilient gasket may be affected by temperature changes or thermal stresses, enabling them to withstand extremes of temperature and thermal shock. (P.O. Box 2, Lincoln.)

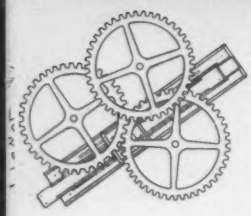
From the products of the sintering division of **John Rigby & Sons Ltd.**, part of the display will be devoted to oil-impregnated bearings. The company manufactures intricate components by the metal sintering process, but the exhibits will also include many samples of precision cold-drawn sections and pinion rod, in which this company specialised. One item of special interest is a cold-drawn helical pinion rod used in automobile instrumentation. Other items expected to be featured are samples of high-duty spring wires from the range of general wire products manufactured by the group (Rawfolds Wire Mills, Cleckheaton, Yorks.)

The **Sheepbridge Group** will be showing products of three of their companies. Sintered Products Ltd. will be showing some Porosint sintered metal filters, as well as a new filter material—Porosint Regimesh—which is a woven wire mesh made rigid by furnace welding the wires at all contact points. It is available in stainless steel, Monel, Nimonic 75, bronze and nickel. Uses for this are for the distribution of de-icing fluid on the leading edges of aircraft, as a catalytic bed, for protection of instrumentation at high temperatures and for thermal insulation at low temperatures.



Filter elements embodying Porosint Rigimesh filter material—on Sheepbridge Engineering stand.

Sheepbridge Alloy Castings Ltd. will display a range of products made from heat-resisting steels of the Thermax range, corrosion-resistant steels and examples of shell moulding. An interesting feature will be centricast tubes available in



lengths up to 10 ft. with diameters between 3 in. and 3 ft.

Sheepbridge Stokes Ltd. will feature a range of centrifugally cast iron products; cylinder liners, piston rings and other products illustrate their versatility. Induction hardened liners are the latest addition to the range, these being hardened in the bore by induction heating and spray quenching. (Chesterfield.)

Sintered Metal Components (Chard) Ltd. are showing a wide variety of engineering components of both simple and complex shapes in a variety of materials. Of particular interest will be a pair of matched cams used in a heavy motor vehicle in the braking mechanism and fitted adjacent to the hydraulic cylinder and brake pedal. One of the cams is bronze and the mating cam is in iron, and by using a sintering process greatly increased efficiency has been obtained in performance together with a tremendous saving in cost. (Boden Works, Chard, Som.)

Thermo-Plastics Ltd. will be exhibiting a standard range of glass fibre laminates in six opaque standard colours, together with examples of patterned laminates. The main feature of the stand will be a reinforced condenser water box mounted on a test rig enabling visitors to see the high-pressure conditions under which the unit can be worked. Other items on view will be components produced by vacuum forming, injection and compression moulding and sheet fabrications. (Luton Road Works, Dunstable.)

Products shown on the stand of **Small & Parkes Ltd.** will illustrate the many various forms and materials which can be associated with friction materials. Sinterdon, for example, is a sintered metal friction material, while Don woven and moulded brake and clutch linings are asbestos-based. In addition to these materials, a range of glands, packings, jointings and asbestos textiles will be shown together with various beltings and narrow fabrics. (Hendham Vale Works, Manchester, 9.)

The choice of bearings has always presented design engineers with many conflicting problems, one in particular being space limitations usually associated with high loading conditions. An answer to this may often be found in needle-type bearings, and in this respect the exhibits of the **Torrington Co. Ltd.** will be of considerable interest, since they illustrate the many advantages which can be gained from their compactness and light weight.

In order to present these aspects and to permit closer inspection of the various types of bearings, a new form of showcase will be used in which a magnifying glass will be incorporated, picking out by suitable illumination many of the bearing details. (Torrington Avenue, Coventry.)

United Coke & Chemicals Co. Ltd. are exhibiting three developments of interest to engineers. Orkot resin-bonded fabric bearings, bushes and rolls will form a main feature. This bearing material, which was originally developed for rolling-mill bearings, is now finding wide use in all branches of the engineering industry. It is light and tough, and coefficients of friction with both conventional and unconventional lubricants are unusually low. In addition, various modifications can be supplied suitable for dry-running bearings.

In another section of the exhibit Orkast polyester resins are featured. A wide range of items made with this versatile structural material is shown, the accent being on materials handling. (P.O. Box 136, Handsworth, Sheffield, 13.)

Henry Wallwork & Co. Ltd. have a mechanised foundry handling medium and large quantities of castings up to 400 lb. in three grades of controlled iron known as Ferronite, and on their stand will be typical foundry products.

Details will also be shown of the new "Plant Four" system which will come into operation in the summer of 1960. This new plant, handling at first uncored castings up to 25 lb., is fully automatic, dealing in sequence with the process of high-pressure moulding, closing, casting, knocking out, cooling and shot blasting. A high rate of production can be achieved with casting accuracy and finish. (Redbank, Manchester, 4.)

Charles Weston & Co. Ltd. are exhibiting their standard range of oil seals, including single, double, tandem and external seals of leather and synthetic rubber. Other types include the Weston split seals for heavy-duty service such as rolling mills, oil engines and gearboxes for traction purposes and those which are

Type CBA Impax seal made by Charles Weston & Co.

used extensively in marine applications such as stern tubes.

Also exhibited are two ranges of Impax seals, both varieties sealing most liquids and gases at very high pressure speeds and temperatures, the high pressures being accommodated by an ingenious method of pressure balancing. (Douglas Green, Pendleton, Salford, 6.)

The stand of **Henry Wiggin & Co. Ltd.** will take the form of an information desk containing a full range of the available technical publications relating to the range of materials produced by the company. Information about the many high-nickel alloys can also be obtained there. (Thames House, Millbank, London, S.W.1.)

The castings exhibited by **John Williams of Cardiff Ltd.** have been chosen to demonstrate the wide applications available for S.G. and alloy iron. These include S.G. iron crankshafts, Ni-Resist manifolds and turbo-blowers for high-speed diesel engines, non-magnetic castings for automatic train control, and Ni-Resist castings used in the aircraft and nuclear engineering industries.

The castings demonstrate the wide range of production facilities available in the foundry division, which can deal with long or short runs, all production being under close metallurgical control. (East Moors Road, Cardiff.)

Wilmot Breeden's highly developed techniques for the manipulation of stainless steel and high-duty alloys in the cold state will be illustrated by the Truflo range of buttweld fittings for light wall piping systems in chemical and petrochemical installations, by hollow inlet guide vanes for gas turbines and by heat exchanger matrices. Also on display will be the Velflo range of fittings for high-velocity air-conditioning systems, wind-tunnel-developed propeller fans and stainless-steel tiles.

Telehoist Ltd., an associate company of Wilmot Breeden, will be showing their Telesig range of screw pumps and hydraulic control equipment. (13-14 Oxford Street, Birmingham.)

The Zinc Alloy Die Casters Association will show examples of pressure die castings in zinc alloy to B.S. 1004 and in aluminium alloy. The castings have been chosen to illustrate their very wide range of uses in the motor industry, household equipment, electrical and electronic apparatus, general engineering, aircraft, toys, etc.—in fact, wherever there is a demand for quantities of strong, accurate components which may or may not need a decorative finish. These exhibits have been contributed by members of the Association. In addition, the stages in the production of the high purity zinc alloy—on which the consistent qualities of modern zinc alloy die castings depend—are shown (34 Berkeley Square, London, W.1.)

Other organisations which will be exhibiting at the exhibition include **British Steel Founders' Association, Cooper & Co. (Birmingham) Ltd., Ferranti Ltd., Firth-Vickers Stainless Steels Ltd., Magnesium Industry Council, Midland Silicones Ltd., Morgan Crucible Co. Ltd., National Street Foundry (1914) Ltd., John A. Smith Ltd. and Vickers-Armstrong (Engineers) Ltd.**

HEAT-RESISTING STAINLESS STEELS

Engineering Materials and Design

DATA SHEET No. 32

1 C 0·40 max.
Cr 13·5
Ni 13·5
W 2·25
Si 1·5
Mn 0·60

2 C 0·25 max.
Cr 24·5
Ni 13·5
Si 0·85
Mn 0·60

3 C 0·20 max.
Cr 28·0
Si 0·50
Mn 0·30

4 C 0·25 max.
Cr 17·0
Ni 33·5
Si 0·75
Mn 0·40

5 C 0·20 max.
Cr 14·5
Ni 64·0
Si 1·00 max.
Mn 0·85

6 C 0·25 max.
Cr 24·5
Ni 13·5
W 2·75
Si 0·85
Mn 0·60

7 C 0·12
Cr 20·0
Si 0·50

8 C 0·10 max.
Ni 79·0
Cr 19·5
Si 1·00 max.
Mn 0·85

PHYSICAL PROPERTIES

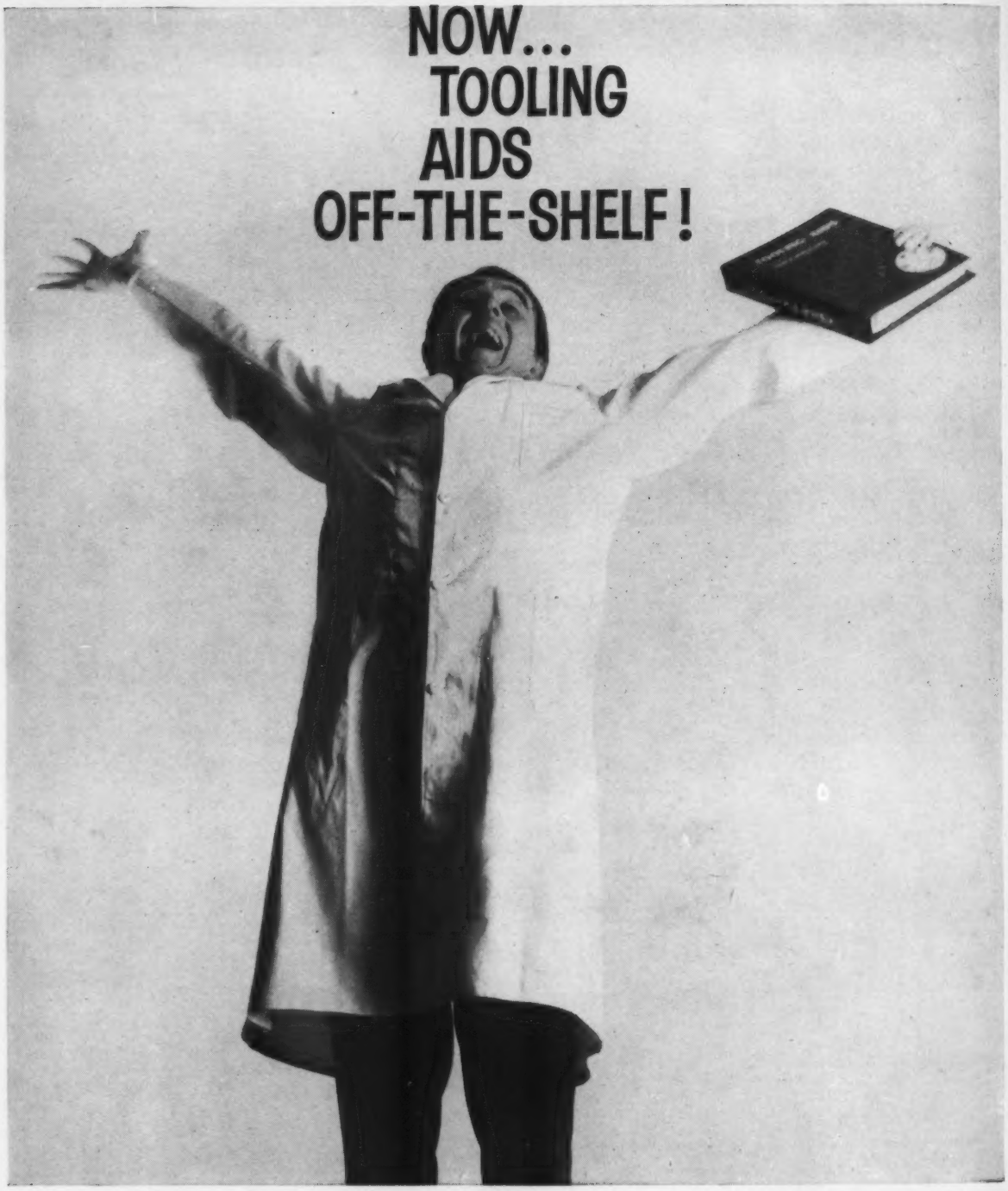
	Melting Point °C.	Specific Gravity	Specific Heat cal./°C./gm.	Thermal Conductivity c.g.s. units at 20°C.	Electrical Resistivity microhm./cu.cm. at 20°C.	Coeff. Thermal Expansion 15–200°	15–500°	15–800°
1	1,400	8·00	0·12	0·033 (0·075 at 1,000°)	78 (109 at 1,000°)	0·0000171	0·0000180	0·0000185
2	1,400	7·90	0·12	0·030 (0·076 at 1,100°)	88 (113 at 1,100°)	0·0000155	0·0000170	0·0000175
3	1,480	7·50	0·115	0·038 (0·063 at 1,100°)	88 (126 at 1,100°)	0·0000106	0·0000115	0·0000120
4	1,400	7·75	0·12	0·025	107·5	0·0000154	0·0000169	0·0000176
5	1,400	8·10	0·12	0·030 (0·069 at 1,100°)	105 (110 at 1,000°)	0·0000124	0·0000150	0·0000159
6	1,400	7·90	0·12	0·030 (0·070 at 1,050°)	87 (125 at 1,050°)	0·0000155	0·000016	0·000017
7	1,480	7·70	0·115	0·052	—	0·000011	0·000011	0·000012
8	—	—	—	—	—	0·000135	0·000015	0·000016

SAFE WORKING LOADS (p.s.i.)

°C	550	600	650	700	750	800	900	1,000	1,100
1	11,000	9,000	7,000	5,000	4,000	3,000	1,500	—	—
2	9,000	7,500	6,000	4,500	3,500	3,000	1,000	350	100
3	8,000	6,000	4,500	3,500	2,500	1,750	500	100	—
4	12,000	10,000	8,000	6,000	4,500	3,500	1,500	500	150
5	8,000	6,000	4,800	3,500	2,500	1,750	500	100	—
6	9,300	7,800	6,200	4,700	3,700	3,200	1,040	390	150
7	—	—	—	—	—	—	—	—	—
8	8,100	6,200	5,000	3,500	2,600	1,800	550	130	—

	Max. Service Temp.	Heat Treatment °C			Welding Properties
	°C.	Hot Working (Start)	(Finish)	Softening	
1	900	1,200	900	1,050 (cool quickly)	Very good
2	1,050–1,100	1,200	900	1,050–1,100 (cool quickly)	Very good
3	1,050–1,100	1,100	900	—	Not recom. for welding
4	1,100–1,150	1,200	900	1,050–1,100 (cool quickly)	Fair
5	1,100–1,150	1,200	900	1,050 (cool quickly)	Good
6	1,100–1,150	1,200	900	1,050–1,100 (cool quickly)	Very good
7	1,000	1,100	900	750 (air cool or water quench)	Poor, welds brittle
8	1,100–1,150	1,200	900	—	Good

Data by courtesy Dr. E. Gregory, Edgar Allen & Co. Ltd.



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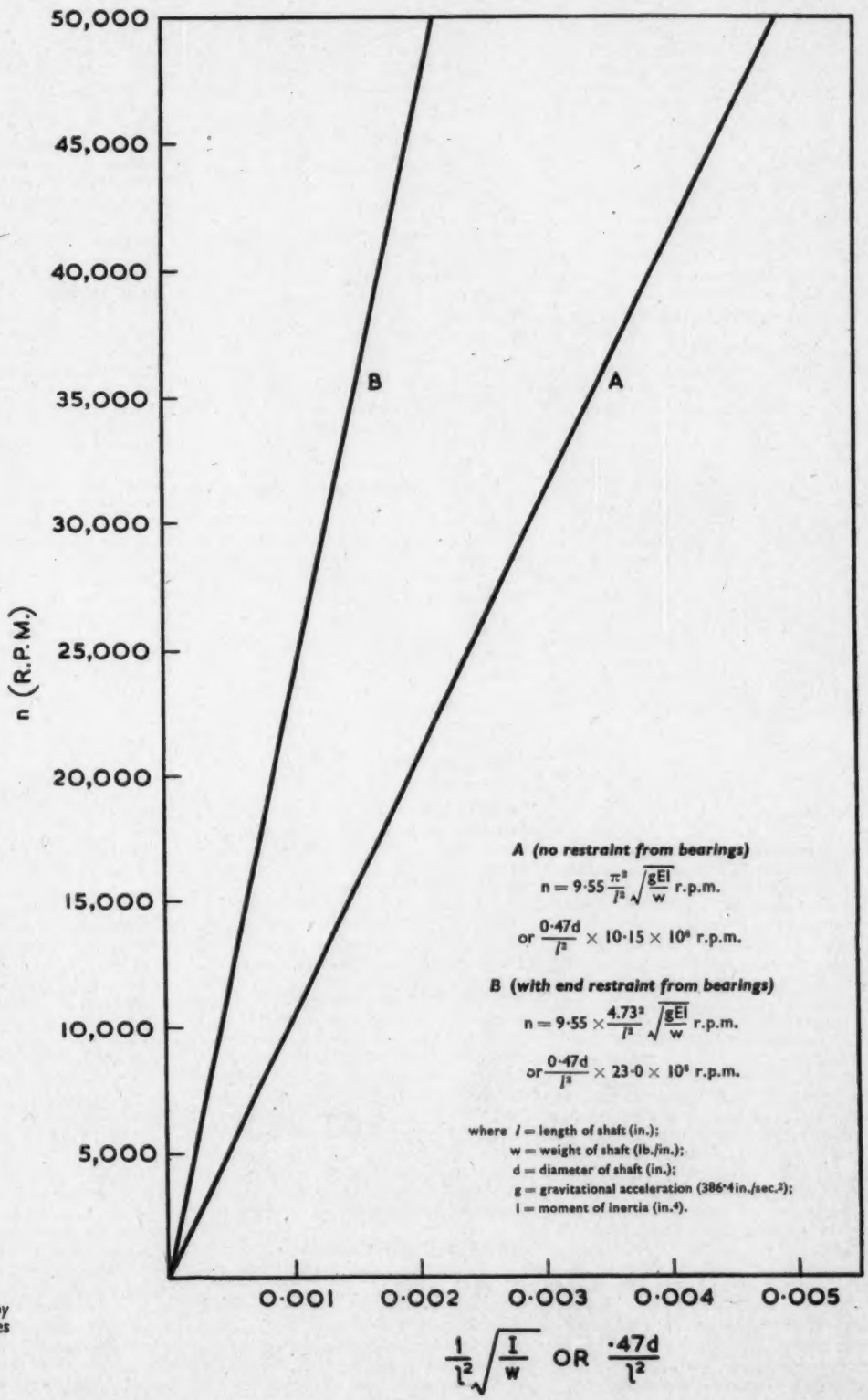
A IMCO Company

CRITICAL SPEEDS FOR SOLID SHAFTS

(Steel E = 30 × 10⁶ p.s.i.)

Engineering Materials and Design

DATA SHEET No. 33



***A* (no restraint from bearings)**

$$n = 9{\cdot}55\,\frac{\pi^2}{l^2}\sqrt{\frac{gEI}{w}}\ \text{r.p.m.}$$

$$\text{or}\ \frac{0{\cdot}47d}{l^2} \times 10{\cdot}15 \times 10^6\ \text{r.p.m.}$$

***B* (with end restraint from bearings)**

$$n = 9{\cdot}55 \times \frac{4.73^2}{l^2}\sqrt{\frac{gEI}{w}}\ \text{r.p.m.}$$

$$\text{or}\ \frac{0{\cdot}47d}{l^2} \times 23{\cdot}0 \times 10^6\ \text{r.p.m.}$$

where l = length of shaft (in.);
w = weight of shaft (lb./in.);
d = diameter of shaft (in.);
g = gravitational acceleration (386·4 in./sec.²);
I = moment of inertia (in.⁴).

Data sheet by
J. A. Coates

Now the N.R.D.C. is justifying itself

Sir,

You seem to have a happy aptitude for hitting important issues squarely on the head. Not long ago I made a proposal that something should be set up on the lines of the N.R.D.C. for the specific purpose of exploiting projects not touched by it. It seems to be generally admitted by those who know that this country is at present losing several thousands of new creative ideas, inventions and technical developments every year. Inventors themselves have long known this to be the position. This is directly contrary to the national interest, national prestige and leadership, and the national economy in terms of export profits and foreign royalties. It is also killing the enthusiasm of creative thinkers and inventors at a time when other countries, especially the U.S.S.R., are laying on special inducements and advantages to workers in this field.

Not everyone, of course, thinks that the N.R.D.C. has done enough to justify its expenditure. Indirect profits and benefits cannot be assessed and they are not always obvious. I do believe, however, that the N.R.D.C. is beginning to justify itself, but the fact that public research developments are now being salved is no excuse for allowing a probably much larger and more profitable field to be wasted.

It is quite clear that we are suffering an immense hidden loss in terms of progress, efficiency and national economic status without agitation, because the facts have never been adequately spot-lighted or understood. Unfortunately, they are not superficially apparent. The conclusion reached in the final paragraph of your leading article (February issue) is therefore extremely pertinent and of great importance.

J. R. C. Moore

Speciality Instruments,
Little Melton,
Norwich.

Sir,

Your contributor Mr. C. E. Newton, in his article "Choosing Electric Motors for Unusual Conditions" (February issue), implies that the Schrage (movable brush type) is the only variable-speed a.c. commutator motor used in practice.

During the last twenty years many thousands of N-S variable-speed a.c. motors have been put into service. There are examples in every industry and several thousand have been supplied for the drive of boiler-house auxiliaries, to quote only one class of application.

The N-S variable-speed a.c. motor can be made for outputs of from one to several thousand horse-power, and with a speed range sufficient to meet all normal requirements (3:1 is common, but much wider ranges can be provided). A shunt speed characteristic is normal, but series characteristic motors are also made. The starting torque when the simplest possible starting equipment is used (i.e., direct switching to the line) is ample for most drives, and other methods of starting can be employed for drives requiring a specially high starting torque.

Speed control is by means of an induction regulator which can be adjusted direct by hand, by remote push-button (controlling a pilot motor actuating the regulator through gearing) or from a wide range of automatic equipment.

A special feature of the N-S motor is its excellent commutation, resulting in long commutator and brush life, due in part to its electrical design and in part to the fact that its brush gear is fixed and therefore the "tracking" is not disturbed as is the case with machines of the movable brush type. Continuous operation for periods of twelve months without attention is quite common and longer continuous operating periods are by no means exceptional.

The motor is available in a range of enclosures, including totally-enclosed fan-cooled and closed-air circuit type with heat exchanger.

In view of the very general use of this type of motor, and of its special advantages for numerous applications, we feel you will wish to correct the erroneous impression given by the article that there is only one type of a.c. commutator motor.

T. J. Barfield

Laurence, Scott & Electromotors Ltd.,
London, W.C.2.

Fuller details of the N-S variable-speed a.c. motor are given in Publication 31/1 *and* L.S.E. Engineering Bulletin, *Vol. 5, Nos.* 2-3, *and some automatic control systems are described in publications* 129 *and* 154.

New Books

Zinc: The Science and Technology of the Metal, its Alloys and Compounds. (*Chapman & Hall, 156s.*)

The substance of this 700-page book is the result of a co-operative effort of the U.S., Canadian and British zinc industries, and has been planned to fully cover the metallurgy of zinc with equal attention to economics, technology and applicability.

As with most monographs, the history and geology of deposits are well covered, as are the subsequent chapters dealing with extraction and refining. More important to the designer are the latter chapters which deal with the processing and uses of zinc and zinc-based alloys, and which contain a wealth of practical information for those concerned either with end products or with protective treatments. Comprehensive references are included.

British Plastics Year Book, 1959. (*Iliffe, 42s.*)

This twenty-ninth edition includes virtually all the information which could possibly be required relating to the plastics industry. Technical terms have been included and greatly assist in the interpretation of terms not in common use, while data sheets covering the main groups of plastics give very comprehensive information. The classified list of raw materials has its own index, the products being alphabetically listed, together with the names of suppliers. Further lists cover similarly manufactured products, plant and equipment.

Trade-marks and proprietary names enable one to locate the manufacture of products which are better known by their trade names, and in addition to the U.K. firms and manufacturers, main overseas companies are included, together with a "Who's Who in the Plastics Industry".

This Year Book is probably one of the most comprehensive of its kind and contains a wealth of ancillary data, such as metric equivalent tables, specific gravities and unit conversions.

Rubber to Metal Bonding. *By Dr. S. Buchan. 2nd rev. ed.* (*Crosby, Lockwood, 42s.*)

Rubber, with its unique properties and the ability to be bonded to metal, finds an important place in engineering design, and in many cases it may be expedient for a company to carry out the bonding operation rather than use a proprietary product.

To the engineer faced with this problem, Dr. Buchan's book is ideal, for it contains all the information necessary, down to the last small detail, to carry out the operations and to predict the final result. The designer may criticise the layout of the book, since what one might think is the most vital chapter, "The Importance of Design", appears at the end of the book, but it should be realised that the real value of this work lies in the wealth of practical detail written with the minimum of pure physics.

Plastic Properties of Rolled Sections. (*British Welding Research Association, 8s. 6d.*)

This is a new guide to the plastic moduli of structural steel members which embodies and enlarges considerably upon information previously published four years ago. It is compiled by Dr. M. R. Horne in the course of work being carried out at the University of Cambridge and deals comprehensively with the plastic moduli, with and without load, of B.S. rolled steel joists, British broad flange beams, universal beam sections, B.S. channels and special channels.

WHAT'S NEW IN MATERIALS & COMPONENTS

P.T.F.E. Adhesive Tape

Adhesive-backed p.t.f.e. tape is now being made available for what is thought to be the first time in this country. Bulk quantities of the tape can be supplied in sizes up to 2 in. width and 0·015 in. thickness, but greater widths and thicknesses are expected to be available in the near future.

The material is said to have good adhesive properties when applied cold, but the surface to which it is to be affixed must be thoroughly cleaned. After the backing paper has been removed, the tape is pressed firmly into position, with pressure applied from the centre outwards to avoid trapping air.

Samples applied to shim steel are said to have shown peel strength of about 2 lb. per in. width and shear strength of between 12 and 20 p.s.i. The adhesive becomes thermoplastic at temperatures above 150 deg. C., but retains useful adhesive attributes up to 200 deg. C. Resistance to acids and alkalis is said to be good, but the adhesive is affected by most organic solvents. A.E.I. (Woolwich) Ltd., London, S.E.18.

EMD 2408 for further information

Aluminised Steel Sheet

As a result of development of a U.K. technique of hot-dip aluminising, a limited range of aluminised steel sheets is now being offered. The makers say that the material can be worked by most of the standard sheet metal working processes, including welding and moderate drawing and stamping.

The material, known as Aludip, is said to have good heat-resisting properties in the medium range of temperatures up to 700-750 deg. C. and to have good corrosion resistance, particularly in sulphurous atmospheres. It is often said that cut edges of various types of coated steel oxidise fairly quickly and subsequently cause serious deterioration of the underlying steel, but in the case of aluminised steel it is claimed that there is no cracking and subsequent flaking of the coating, despite the edges oxidising. The minimum amount of finishing processes after fabrication of the article are said to be needed. Coated Metals Ltd., Palmerston House, Bishopsgate, London, E.C.2.

EMD 2409 for further information

Heat-transfer Medium

Thermex heat-transfer medium is a eutectic mixture of diphenyl oxide and diphenyl in the respective proportions by weight of 73·5 and 26·5 per cent. It is said to be the first heat-transfer medium of this type to be made commercially in the U.K.

A good combination of physical properties is said to make Thermex particularly suitable for liquid-phase and vapour-phase heating and cooling in a variety of industrial processes. It is said to have a high boiling point (255 deg. C.) and low freezing point (12 deg. C.) and excellent thermal stability over long periods up to 400 deg. C. It is claimed to have high heat-transfer coefficients, particularly in the vapour phase, to be non-corrosive and to present a negligible fire risk.

In vapour-phase heating very accurate temperature control may be achieved simply by regulating the pressure. A single Thermex boiler may be used simultaneously for several different consuming points by adjusting the pressure at each point to give the desired temperature.

Uses for which it is recommended are melting and spinning synthetic fibres, distillation and processing of fats, vegetable oils and petroleum fractions, manufacture of paints and varnishes, etc. I.C.I. Ltd., Imperial Chemical House, Millbank, London, S.W.1.

EMD 2410 for further information

Phosphating Solution

A new processing technique involving a combined degreasing and phosphating solution has been developed. This is called Waltersolv, and may be added to the phosphating baths which are made up in the normal manner. It consists of degreasing and emulsifying agents in solution in a high boiling point fraction derived from petroleum. This has a flash point of 120 deg. C. and a boiling point of 260-290 deg. C. Because of its high boiling point, very little of the Waltersolv is said to be lost by evaporation; replenishment of the amount removed by drag-out is necessary from time to time. Walterisation Co. Ltd., Purley Way, Croydon.

EMD 2411 for further information

Aerosol Lubricant

An addition has been made to the range of Ambersil Electrospray, which contains a silicone fluid with a rust inhibitor, specially formulated for use in applications which are prone to condensation and corrosion. The silicone film is said to exclude moisture and to render treated surfaces water-repellent, while the rust inhibitor prevents corrosion for a long period. The aerosol pack gives a fine spray, providing an even coating and penetration into inaccessible places.

It is a clear fluid claimed to have good heat stability, high resistance to oxidation, high flash point and low volatility. Amber Oils Ltd., 11a Albemarle Street, London, W.1.

EMD 2412 for further information

Phenolic Resin Foams

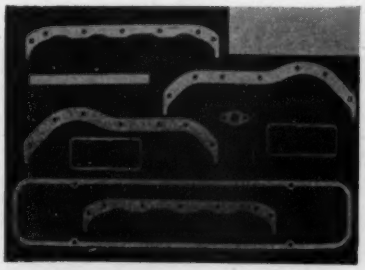
A low-density cellular material recently developed for use in thermal insulation and as a lightweight core material for building panels has been announced.

The phenolic resin, foaming agent and hardener can be mixed and then poured into a mould for making into large blocks for cutting into slabs; alternatively, the mix can be poured into cavities for foaming *in situ*. The complete mixing and foaming process is said to take less than 10 min. and the foams, which are believed to be unique in the plastics foam field because they do not support combustion, can be made into densities from 1 lb./cu. ft. upwards. Bakelite Ltd., 12-18 Grosvenor Gardens, London, S.W.1.

EMD 2413 for further information

Cork/Rubber Gasketing

A new type of gasketing material based on a cork/nitrile rubber compound has recently been introduced. It consists of high-quality, smooth-texture cork intimately mixed with Hycar nitrile



rubber. It is said to be completely impervious to oils and greases, each cork granule being individually enclosed by the Hycar binder.

The gasketing is made with a wide range of operating temperatures with a maximum of 150 deg. C., and it is said to be dimensionally stable under normal conditions of temperature and humidity.

Appreciable solvent resistance is claimed and it is therefore said to be particularly suitable for general-purpose applications involving the following fluids: mineral oil detergent and viscosity stabilised oils, ester-based lubricating oils, petroleum fuels, aqueous coolants and anti-freeze solutions.

Hycar/cork gasketing is claimed to be superior to ordinary cork material, exhibiting better ageing under all conditions and combining the compressibility of cork with the recovery properties (resilience) of nitrile rubber—without the uncontrollable side flow usually associated with natural rubber.

It is also said to have excellent fatigue resistance, and is thus ideal for applications involving frequent opening and resealing; it is said to resist fungal attack and to be dimensionally stable. Four grades are available in sheet form from 0·031 in. thickness upwards. British Technical Cork Products Ltd., Reading.

EMD 2414 for further information

Men with a lot of liquids to handle know that with ENSECOTE size is no obstacle. Full ENSECOTE protection can now be applied economically to almost any size of tank. For stoving, we have one of the largest furnaces in the country—it's all part and parcel of our major development programme. We can also of course make and erect the tanks—*any* kind of tanks, including fibre glass, P.V.C. and polythene—often saving you time and money.

ENSECOTE linings protect almost anything you can put into a tank. They are easily cleaned and sterilized, completely odourless and tasteless, and will add years to a tank's life.

ENSECOTE *Lithcote* PLASTIC LININGS

For literature and technical advice write to: NEWTON CHAMBERS & CO. LTD., THORNCLIFFE, SHEFFIELD, ENGLAND

Agents in Belgium, France and Holland: FOURS LECOCQ ET ATELIERS DE TRAZEGNIES REUNIS, S.A., TRAZEGNIES, BELGIUM

Laminated Wood Flooring

This material, known as Permatred, made from beech veneers, impregnated and densified under vacuum with thermo-setting resins, is being recommended for a variety of engineering applications. The makers claim that it is light in weight, rot-proof and waterproof, and can be scrubbed daily without deteriorating. It is suggested for use on boats, diesel-electric locomotives and vans, and its resistance to wear, splintering and delamination are said to make it ideal for trucks. Grooved chequer plate surfaced sheets are available 60 × 36 in., in thicknesses of ¼, ⅜, ½, ⅝ and ¾ in. Alternative surfaces are being developed and special thicknesses can be supplied to customers' requirements. Permali Ltd., Bristol Road, Gloucester.

EMD 2415 for further information

Expanded Neoprene

Rubazote expanded neoprene is a development of Rubazote (soft expanded rubber) and has a similar closed-cell structure. It will, in addition, resist oil and petrol. It is claimed to withstand temperatures from −40 to +70 deg. C. and to have better ageing properties when exposed to natural light.

Many important applications in industry are recommended, and it is said to be particularly suitable for seals and resilient pads in exposed situations adjacent to heat sources, or where there is a risk of contamination from oil, petrol or grease. Expanded Rubber Co. Ltd., Mitcham Road, Croydon, Surrey.

EMD 2416 for further information

Seal Material

Hy-Clad is a specially treated metal sheet, usually light alloy, with a layer of rubber bonded to one or both faces. It is said to possess many advantages over existing sealing materials for re-usable washers and gaskets and the integral bonding of seals to access panels, handhole covers, etc. It is claimed that the rigidity of Hy-Clad seals enables them to be removed and replaced many times without damage, while the elasticity of the rubber layer gives a very high degree of compressibility with no "creep" or "flow" beyond the limits of the joint face. Alternative rubbers used in the manufacture of Hy-Clad include natural, nitriles, neoprenes and silicones. It is available in sheets, 12 × 12, 18 × 12 and 24 × 24 in. using 16 or 26 S.W.G. light alloy and with rubber thicknesses of 0·20, 0·25 and 0·30 in. to ±0·003 in. Fireproof Tanks Ltd., The Airport, Portsmouth.

EMD 2417 for further information

Variable-speed Gearbox

A specially-converted Westinghouse hydraulic torque converter is now being offered housed in a robustly-made, oil-filled case designed to facilitate mounting and connection to all standard machinery drive arrangements. Basically, the unit is a back-to-back mounted, oil-submerged, variable-displacement hydraulic pump on the input side which feeds a reversible fixed-displacement hydraulic motor on the output side. A change-over valve in the supply lines to the motor provides instantaneous reverse at any speed. Full output power and speed is obtainable in either direction.

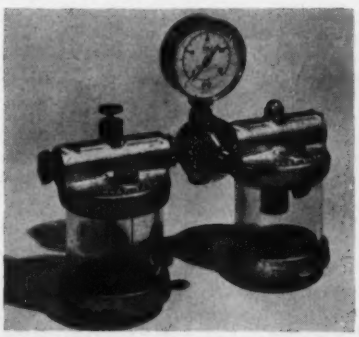
It would appear to be suitable for lathe head drives, workshop variable-speed take-off for drilling machines, etc., and for use as a transmission unit in experimental set-ups.

Recommended input speed is 500-1,000 r.p.m. A very fine selection of output speed at constant torque from zero up to 6 per cent below input speed is claimed. Maximum input power is 1¼ h.p. Both shafts are ⅜ in. diameter and these are fitted with Woodruff keys. Size is approx. 8 × 10 × 12 in. long. Proops Bros. Ltd., 52 Tottenham Court Road, London, W.1.

EMD 2418 for further information

Oil Mist Spray Equipment

An oil mist unit (model M.3892) for the application of cutting oils enables soluble or neat coolants to be fed to the work face in circumstances where surface



speed normally makes dry machining necessary. It functions by delivering a fine mist of coolant in a stream of compressed air.

The unit operates at 10-20 p.s.i. and consists of three major components: a porous bronze filter element; a pressure-reducing valve complete with gauge, to indicate the reduced air pressure; and an Ayrlyne lubricator with flow adjustment.

The lubricator embodies a ½- or 1-pt. transparent oil reservoir with needle regulating valve controlling the oil flow. The ratio of oil to air can be adjusted by a regulating screw at the top of the lubricator.

The unit is suitable for use with neat cutting oils of a viscosity not exceeding 300 Redwood seconds at 70 deg. F. or with soluble oil emulsions. Wakefield Castrol Group, Castrol House, Marylebone Road, London, N.W.1.

EMD 2419 for further information

Flame Detector

Recently developed is a flame detector which, because it responds only to ultra-violet light, will not register anything except genuine flames or electric sparks.

The Ultravision, as the new instrument is called, relies on a photocell which sees and is activated only by ultra-violet radiation in the waveband 0·2-0·26 microns. This waveband is present in all flame and electric sparks. The Ultravision is said to be completely insensitive to infra-red and visible radiation, which is set up by hot refractory or reflected light from other sources. The new device is claimed to detect even ignition electrode sparks.

The flame detector is now available as a complete unit incorporating its own heat block, amplifier and seal-off. It can be placed anywhere in a furnace to control either pilot or main flames, or can be situated so as to control both.

It can be used for oil- or gas-fired burners and can be directly substituted for the flame detector in rectification systems. The photo-cell can also be adapted for any type of process control where ultra-violet radiation is a factor. Honeywell Controls Ltd., Ruislip Road East, Greenford, Mx.

EMD 2420 for further information

Nylon Suspensor

This is a suspension unit for cable or hose designed to support them and prevent them being torn away from couplings or other apparatus. It is said to be particularly suitable for power tools where accidental tear-away has always been a problem. One end of the suspensor is fixed to the apparatus and the other end slipped over the cable or hose which it is said to grip, however smooth the surface and whatever the material. They are supplied with three types of ends—namely, lug, loop and gland—offering a variety of anchoring methods. A wide range of sizes enables tubes from 0·29-1·7 in. diameter to be accommodated. Worcester Fabrications Co., St. John's Works, Worcester.

EMD 2421 for further information

Peak Pressure Indicator

This unit automatically registers on a calibrated sleeve the maximum of firing pressures on a diesel or internal-combustion engine.

It is claimed to eliminate the liability of error due to personal judgment and can therefore be easily used by semi-skilled or even unskilled personnel. It is consequently ideally suited for use in the field, and is said to be of great value to the service or maintenance engineer, as it readily brings to notice unequal cylinder loading due to leaking piston rings or valves, and in diesel engines unequal metering of fuel, choked atomisers, etc. Faults can thus be spotted at an early stage and measures can be taken to guard against costly breakdowns and repairs.

A high-pressure model of the indicator is also manufactured for the measurement of diesel fuel line pressures. Dobbie McInnes Ltd., 191-3 Broomloan Road, Glasgow, S.W.1.

EMD 2422 for further information

Spider Coupling

The Holset rubber spider-type coupling has been designed to meet a need for a heavy-duty coupling suitable for applications driven by flange-mounted motor units. It is a development of the maker's standard rubber block coupling. The rubbers are moulded in the form of a spider and there is no bolted connection.

The construction is particularly suitable for the blind assembly of the flanged motor to the housing of the driven machine. The installation is effected by the axial movement only of one of the connected machines.

This coupling uses rubber in compression and the makers claim the same excellent shock-absorbing properties and capacity for misalignment as for their standard types. The small overall size makes it useful for rolling-mill run-out table rollers where the coupling and motor may be under the floor, and the fact that lubrication is not required is helpful in these and other drives where access is difficult. Other applications are the vertical drives of mixers and centrifuges and diesel generator sets, etc. Sizes are in production up to 22 h.p. at 100 r.p.m. The Holset Engineering Co. Ltd., Turnbridge, Huddersfield.

EMD 2423 for further information

Aluminium Cable

Solidal has been designed and developed as a cable to give a saving in manufacturing cost and to offer advantages in jointing and handling.

It is based on solid, shaped conductors of fully-soft aluminium, affording the maximum compactness and the use of the minimum quantity of insulating material. Each sector-shaped core is insulated by an extruded p.v.c. coating, and the conductors are laid up with a right-hand lay; pre-twisting of the conductors has not been found necessary. The laid-up conductors are lapped with a clear p.v.c. tape to a thickness of 0·04 in. Outside this is a single layer of rectangular, hard aluminium wires applied with a left-hand lay, their total cross-sectional area being equal to that of one of the cores. These wires are said to give very effective mechanical protection to the cores, and provide an excellent low-resistance screen to prevent dangerous electrical leakage in the event of severe damage. They are also designed to serve as the neutral conductor.

Over the neutral/armour wires may be laid a right-hand-lay tape of 0·005-in. aluminium foil to equalise current distribution in the wires. This refinement, required by certain continental specifications, ensures a low-resistance path for any fault current that might be flowing to any one of the wires, and avoids the danger of the wires being insulated one from the other by inward penetration of the outer sheath.

Over the current-equalising tape a barium chromate linen tape may be wound to give chemical protection to the wires against attack by soil electrolyte in

the event of the outer sheath becoming damaged during installation. Northern Aluminium Co. Ltd., Bush House, Aldwych, London, W.C.2.

EMD 2424 for further information

Explosion-proof Statotherm

The Stabilag range of coarse temperature controllers has been augmented by the addition of an explosion-proof model of the Stratotherm energy regulator. It is suitable for use in hazardous and flame areas and has passed stringent inspection regulations.

The unit is designed to take a maximum loading of 2 kW. and can be used on a 220/230-volt supply; it regulates to infinity the electrical input between 10 and 100 per cent of the rated consumption. The mean heating output achieved with the regulator is obtained by intermittent operation corresponding to the time for which the controlled appliance is switched on and off. The Stabilag Co. Ltd., Mark Road, Hemel Hempstead, Herts.

EMD 2425 for further information

Solar Cells

A new series of ruggedised silicon photo-voltaic cells is claimed to have high efficiency and to be capable of converting up to 9 per cent of the radiant energy falling on to the cell surface. New alloying techniques are said to be used in the manufacture of these cells with the object of producing a permanent bond between the contact and the silicon wafer. This bond, therefore, enables the contact to become an integral part of the cell itself, whilst still allowing soldering of the individual cells. The improved bond is said to result in reduced series resistance and higher operating efficiency. The cells are supplied in a range of three nominal active areas from 0·37 to 1·75 sq. cm., the overall dimensions being $\frac{1}{2} \times 1$ in. and 1×2 in. respectively. International Rectifier Co. (Great Britain) Ltd., Hurst Green, Oxted, Surrey.

EMD 2426 for further information

Angle Seat Valve

An angle-seat free-flow valve now available can be manufactured from several types of thermoplastic materials in sizes from $\frac{1}{2}$-1 in. B.S.P. The construction of these units is claimed to be very sturdy and to allow for speedy replacement of seatings under normal service. Barflo Ltd., 56 Cavendish Place, Eastbourne.

EMD 2427 for further information

High Vacuum Valves

A new type of hand-operated straight-through high vacuum valve is announced. Available in four sizes—1, 2, 4 and 6 in.—it is a compact aluminium casting which can be used down to pressures of 10^{-4} mm. Hg. absolute. When open, the valve disc is withdrawn completely into the valve body to give full unobstructed passage through the valve. The valve is closed by rotating the lever through 180 deg. and the valve plate is locked in the closed position. The valve is leak-tight and can be used with atmospheric pressure on either side of the valve plate. Because the valve is very thin (the 6-in.-bore valve measures only 4 in. across flanges) it can be used where space is limited. An air-operated version is also available.

The valve is used where high conductance or an unobstructed opening is needed, e.g., with diffusion pumps, in pumping lines and vacuum locks. Special adaptor flanges can be supplied which enable the valve to be coupled to existing equipment. Vacuum Research (Cambridge) Ltd., Quayside, Bridge Street, Cambridge.

EMD 2428 for further information

Relief Valve

A new relief valve—the 10HV—has a working temperature of 0-100 deg. C. and

is designed to meet the demand for a compact and stable pilot-operated relief valve capable of accepting flows of up to 10 gal./min. with a pressure range of from 100-3,000 p.s.i. Outstanding feature claimed for the valve is its flat characteristic over a wide flow range. Plessey Co. Ltd., Ilford, Essex.

EMD 2429 for further information

Adjustable Needle Bearing

An adjustable cage-guided needle bearing has been introduced to cater for the precision requirements of the machine tool designer. It is of three-part construction, i.e., outer race, brass cage and needle rollers. The advantages of the cage-guided-type needle bearing have been incorporated with a specially designed outer race which enables the internal clearance of the bearing to be finely adjusted during operation. A screwed ring not only provides means of adjustment, but ensures that the bearing is seated correctly by presenting a true 90-deg. face to the edge of the outer race. A clamping ring locks the screwed ring after positioning. When adjustment takes place, the two tracks of the outer race take up a slightly crowned shape, and thereby reduce the internal clearance. INA Needle Bearings Ltd., Dafen, Llanelly, Carms.

EMD 2430 for further information

EMD 2340 for further information

Expansion, contraction and lateral movement of pipe work under extreme conditions of temperature and pressure is no problem to the engineer who has been wise enough to contact and consult TEDDINGTON technicians. Teddington Bellows Expansion Joint cylinders are butt-welded from highly finished cold rolled stainless steel sheet. Convolutions are introduced to give the bellows their characteristic flexibility. Nuclear, chemical, marine and gas engineers acknowledge their efficiency and superiority over many older forms of expansion joint. Wherever pipe-work is subjected to vibration or movement in any direction, a Teddington Bellows with a suitable end-fitting will solve the problem.

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Teddington Bellows are produced in technical collaboration with the Solar Aircraft Co., U.S.A.

TEDDINGTON BELLOWS

EXPANSION JOINTS

TEDDINGTON AIRCRAFT CONTROLS LTD. (*Industrial Bellows Division*)
Ammanford, Carmarthenshire. Tel.: Ammanford 2255

AT THE PHYSICAL SOCIETY EXHIBITION

Platinum-coated Refractories

Unglazed ceramic bodies can be coated with a continuous layer of platinum metal by using special platinum preparations which have recently been developed. The platinum is applied in a liquid form, then fired to burn away the vehicle and bond the platinum to the ceramic surface.

Using this technique, layers of platinum of the order of five to ten thousandths of an inch can very readily be produced. It is said that these films, which are bonded to the ceramic body, are not porous and can be used to protect the ceramic surface from corrosive agents such as molten glass.

This is of particular application in the glass-making industry, where it is found that molten glass attacks the refractory container in which it is produced or through which it flows.

Although platinum in sheet form has long been used by the glass industry, its wider application has been restricted by the weight required to clad a refractory surface. The use of "liquid" platinum not only reduces substantially the weight required to protect a given area, but also greatly facilitates its use in special areas most subject to attack by molten glass. Engelhard Industries Ltd., Baker platinum division, 52 High Holborn, London, W.C.1.

EMD 2431 for further information

Variable-speed Coupling

In this device a silicon-controlled rectifier is used to control the current in the field coil of an eddy current coupling unit. The drive on the demonstration unit was a ½-h.p. Adjusto-Speede drive, which incorporates an a.c. induction motor, the variable-speed eddy current coupler and a tachogenerator. The control unit supplies the current to the energising coil of the coupler and determines the degree of slip between the constant-speed motor and the output shaft. The tachogenerator supplies a voltage proportional to the speed of the output shaft, and this is compared with the demand voltage. Texas Instruments Ltd., Dallas Road, Bedford.

EMD 2432 for further information

Surface Pyrometer

The pyrometer offers a solution to the problem of measurement of surface temperatures of rollers, cylinders, etc., that are heated to temperatures in the approximate range 50-150 deg. C. and which are in rotation. Standard surface pyrometers are usually unsatisfactory for this purpose (unless the speed of rotation is very low) because of frictional heating errors and because of wear of the temperature-sensitive bimetallic strip in the pyrometer.

These difficulties are claimed to be overcome in the modified pyrometer by the use of thin strips of p.t.f.e. to front and back the bimetallic strip in the instrument. Thus the pyrometer may be applied to a moving surface without significant frictional effects or damage to the bimetallic strip. In the event of wear or damage to the front strip of film, it is easily, quickly and cheaply replaced. Suitable choice of film thickness for the protective strip is said to enable a rapid and accurate measurement of temperature to be made. Shirley Developments Ltd., 40 King Street West, Manchester, 3.

EMD 2433 for further information

Pressure Transducers

In a range of pressure transducers now available, type NT4-313 is a general-purpose pressure transducer for the medium to high pressure ranges. The flush diaphragm allows direct mounting in liquid or gas streams without the creation of turbulence or the addition of volume to the system being measured. Hermetically sealed absolute versions of this are said to be particularly suited to pressure measurements where corrosive atmospheres exist. Another version, the NT4-317, is said to combine high-pressure ranges with excellent high-temperature characteristics. Solartron Electronic Group Ltd., Thames Ditton, Surrey.

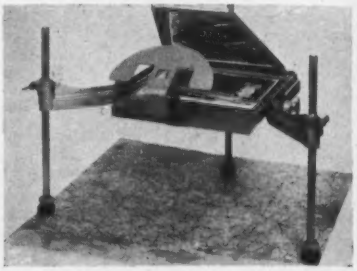
EMD 2434 for further information

Vibration Strain Gauges

These strain gauges are recommended for use in a wide range of applications for the determination and analysis of dynamic strains. The material employed in them is the TCL Grade 3 piezoelectric ceramic, having a wide temperature range, flat temperature coefficient and excellent long-term stability. Being piezoelectric, the gauge is said to be self-generating and thus requires less complex instrumentation than the wire strain gauge. Where slip rings are involved, the high sensitivity and low current requirements are claimed to give a very high signal/noise ratio. The gauges may also be used to generate vibrations in a structure. Technical Ceramics Ltd., Wood Burcote Way, Towcester, Northants.

EMD 2435 for further information

Drawing Comparator

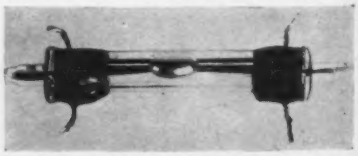


A monocular instrument known as the Vertical Sketchmaster has been designed primarily for the transfer of information on to maps from vertical or moderately tilted photographs. It can be used to effect reconciliation between photographs and maps whose scales differ within the range 2·5:1 and 0·5:1. The instrument can also be used for the transfer of information between drawings of different scales or between drawings and photographs. It operates on the camera-lucida principle, one map or drawing being placed on the platform of the instrument and the other on a table. The images are viewed simultaneously by means of a semi-silvered mirror, and lenses and a peep-sight are provided to overcome difficulties which would otherwise arise when effecting a change of scale. The conditions of viewing the sketch on the platform are fixed, but the distance and angle at which the drawing on the table is viewed can both be altered. Nash & Thompson Ltd., Tolworth, Surrey.

EMD 2436 for further information

Variable Mercury Switch

A new type of mercury switch was shown, comprising integral film resister patterns in the interior to provide continuous response to angle of tilt, and incorporating various novel sealing and contacting features. Patents are pending for this work, which forms part of a development carried out in conjunction with the R.A.E., Farnborough. G. V. Planer Ltd., Windmill Road, Sunbury-on-Thames.



EMD 2437 for further information

News of Industry

The **Council of Industrial Design** is organising a one-day conference on "Industrial Design and Textile Machinery" to be held at the British Rayon Research Association, Manchester, on March 17. The conference will discuss the value of industrial design from the machinery user's point of view, the relation between design and technological developments in industry, and the role of the industrial designer in the textile machinery industry.

We regret to announce the death of **Mr. F. G. Alletson Cook**, editorial representative in New York of ENGINEERING MATERIALS AND DESIGN and other Heywood journals.

I.C.I. Ltd. have announced a further reduction of 3d. per lb. in the price of Alkathene (polythene) for the U.K. market. Standard price is now 2s. 3½d. per lb.

Standard-Triumph vehicles are to be assembled and manufactured in Belgium, starting next June. A site has been purchased by the company at Malines, and initial production is expected to be at the rate of 2,500 units a year.

Roto-Finish Ltd. have announced a merger with N.V. Roto-Finish Maatschappij of Holland, so that the companies now become a combined Anglo-Dutch enterprise.

G.E.C. Ltd. have received an order from the British Iron and Steel Research Association for a vacuum melting furnace. The furnace has a melting capacity of 56 lb. and is to be used for research into the vacuum melting and casting of ferrous metals. It has a working pressure of 1 micron Hg. and it is designed for a working temperature of 1,700 deg. C.

The **British Transport Commission** is to hold a conference in October with the title "British Railways' Electrification Conference, 1960". An exhibition, to be held concurrently in London, will be the largest and most comprehensive assembly of electric rolling-stock and railway electrification equipment ever displayed in this country. The object of exhibition and conference is to show railway administrations throughout the world what B.R. are achieving in a.c. electrification, and to exchange views with them.

The **Council of Industrial Design** has been awarded the Great International Golden Compasses Award for 1959. This is given by Italy's largest departmental store, La Rinascente, for an outstanding achievement in industrial design in any part of the world.

An exchange of technical assistance, advice and personnel has been agreed by the **Armour Research Foundation** (of the Illinois Institute of Technology) and **Toegepast Natuurwetenschappelikj Onderzoek** (T.N.O.). T.N.O. is jointly financed by the Dutch Government and industry. Under the terms of the agreement, each organisation will be able to call on the other for non-proprietary information concerning research data, techniques and equipment. Joint research projects may also be considered.

Both organisations employ more than 1,000 research scientists and supporting personnel.

Nylon sections weighing up to 400 lb. have been produced by the Polymer Corp., U.S. parent company of **Polypenco Ltd.** Claimed to be the largest ever produced, these are soon to be supplied on a production basis and will be fabricated by Polypenco. Shapes of 36 × 2¼ × 102 in. have been produced in the U.S. in limited quantities.

Kaiser Aluminium & Chemical Corp. and the Delta Metal Co. Ltd. have formed a new company known as **James Booth Aluminium Ltd.** It will take the place of James Booth & Co. Ltd., a Delta Metal subsidiary. It is expected that there will be expansion of the company's Kitts Green works at Birmingham and its range of wrought aluminium products.

Kelvin & Hughes Ltd. and the Curtiss-Wright Corp. of America have signed an agreement for the exclusive right to manufacture and sell the non-destructive testing equipment of the other partner. This includes instruments for the inspection and measurement of materials, and equipment employing ultrasonic techniques in all industrial fields.

Wayne Kerr Laboratories Ltd. have established a special section devoted to industrial and scientific measurement. The section, known as the applications group, may be consulted for an advisory service or to develop new instruments into fully engineered form.

A substantial share interest in **E.M.O. Instrumentation Ltd.** is to be acquired by the Barden Corp. of the U.S.A. Both companies manufacture precision ball bearings.

Next stage in the development of the **Firth Brown** forge development scheme at Sheffield is to be the installation of a new 4,000-ton press. Recently, a new shop has also been built for the installation of a 800-ton press, equipped with a 3-ton mobile manipulator and fitted with automatic precision control.

A special delivery service has been announced by **Equipment & Services Ltd.** for urgent deliveries of electrical timing and control equipment; a stock of pre-assembled components of automatic and semi-automatic timers for single or multiple time intervals with one or many contacts is to be made available.

The **Helicopter Association of Great Britain** has now merged with the Royal Aeronautical Society, in which a rotorcraft section has been formed.

The **British Trade Fair** is to be held in Sokolniki Park, Moscow, and a reciprocal exhibition of Soviet goods is to be held in London in 1961. This will be the first time that industrial exhibitions of this kind have been held in the U.K. or the U.S.S.R.

The new automatic plant at the Oldham factory of Ferranti Ltd. for producing diffusion diodes. (See story below.)

A unique automatic plant has been put into operation by **Ferranti Ltd.** in Oldham for the production of their ZS30 series 500-mA. double-ended diffusion diodes. It is estimated that it is capable of producing 43,000 diodes a week. Until recently, most of the production operations of this series were carried out by hand, but all operations in the final assembly of the header, such as flash welding the wire on the back of it, passing through hydrogen furnace to remove oxidation, are carried out by automatic transfer mechanisms.

A permanent display representative of both producing and manufacturing sides of the British rubber industry is being presented to the Science Museum in South Kensington. It occupies three large showcases in the industrial chemistry gallery, and illustrates the molecular structure of natural and synthetic rubbers; their production, compounding, and processing; the great variety of products thus obtained, and the vital part they play in modern life.

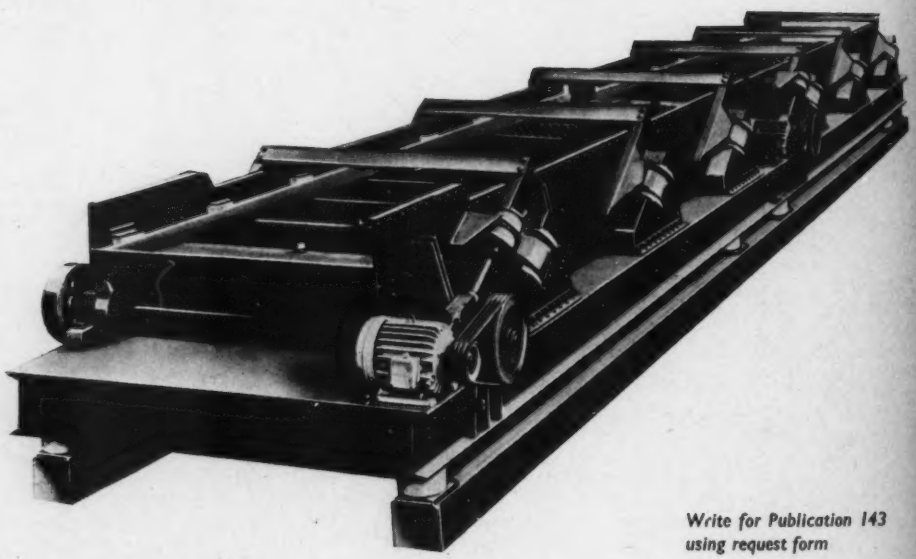
The display has been devised and organised by the **Federation of British Rubber and Allied Manufacturers** and made possible by the generosity of British manufacturers of rubber products; makers of synthetic rubbers, compounding chemicals, processing machinery and components; the Natural Rubber Development Board representing producers of natural rubber; and the National College of Rubber Technology.

A logical development–

EDGAR ALLEN PINTSCH–BAMAG RESONANCE SCREENS

For many years, Edgar Allen & Co. Limited have manufactured crushing, grinding and screening machinery, and now the manufacture of resonance screens, under licence from Pintsch-Bamag of Germany, is a further step in the physical treatment and preparation of raw materials.

These machines are simple and robust, but impart to the material being screened highly accelerating movement with an amplitude which can be adjusted to give maximum screening efficiency.



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